Tappi

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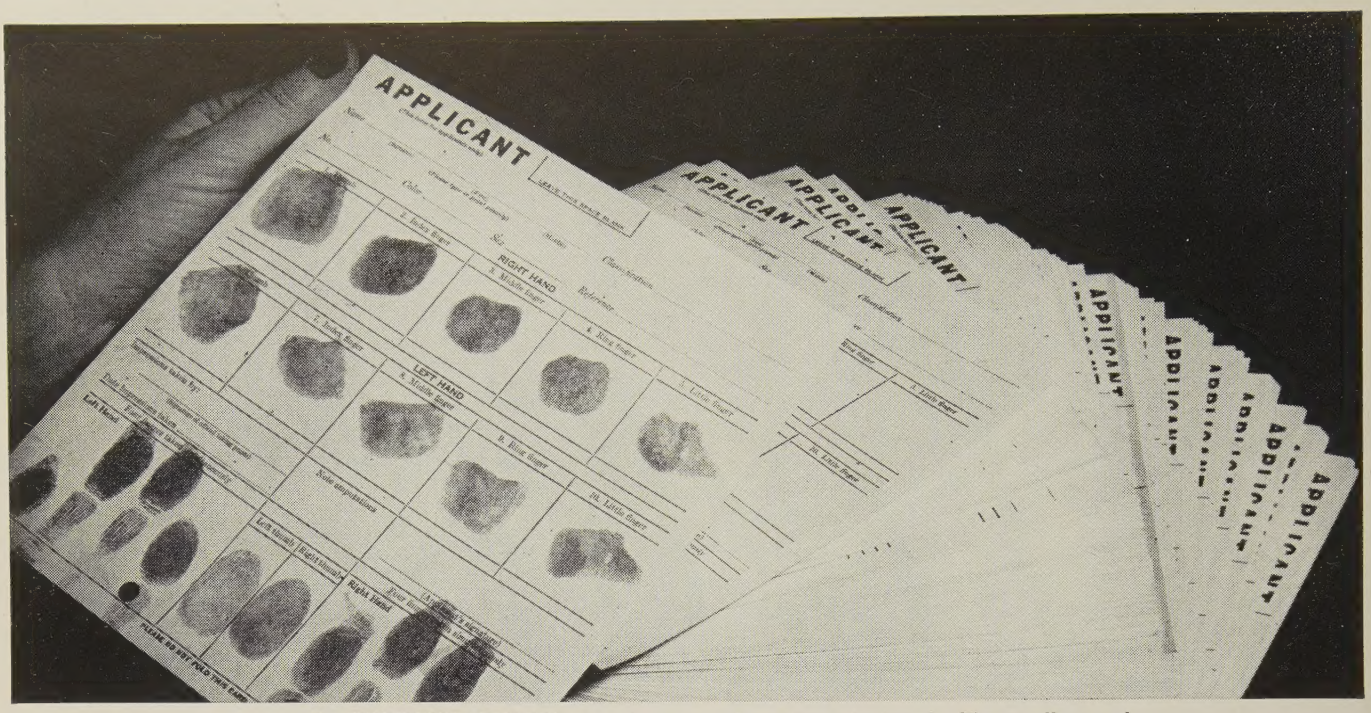
MAY 1955

VOLUME 38 • NUMBER 5

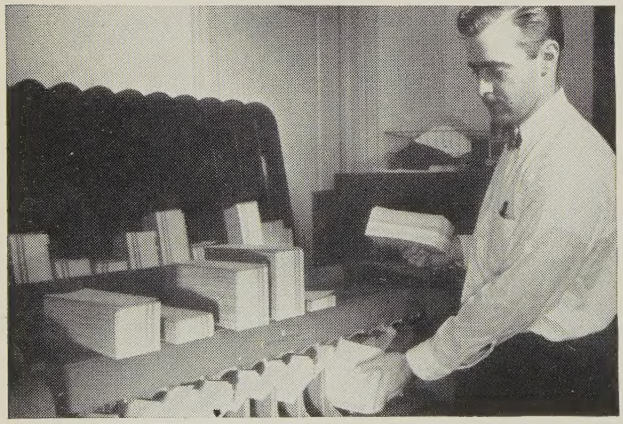


FINGERPRINT RECORDS are well preserved on Pexol-sized cards. The excellent and uniform sizing protects the cards from damage due to handling and accidental wetting.

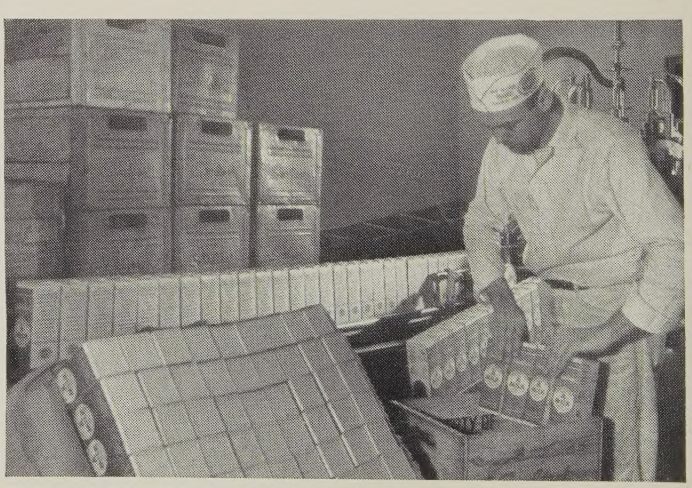
BETTER SIZING THROUGH HERCULES PEXOL®

Paper and board destined for a multitude of end uses do the job better when they have been properly sized. That's why mills rely on Pexol for optimum sizing efficiency.

Like all Hercules papermaking chemicals, Pexol fortified size is available in numerous types to insure that there is one best suited for your own manufacturing requirements. Hercules' extensive research and service facilities put more than forty years of experience in the papermaking industry at your disposal.



FINGERTIP CONTROL of complicated files is practiced with modern automatic machinery. File cards inadequately sized are subject to serious damage or may be useless on becoming wet. Pexol, Hercules fortified size, provides the required protection.



FOOD CONTAINERS require a high degree of uniform sizing. Paper milk bottles sized with Pexol help insure satisfactory performance.

Paper Makers Chemical Department

HERCULES POWDER COMPANY

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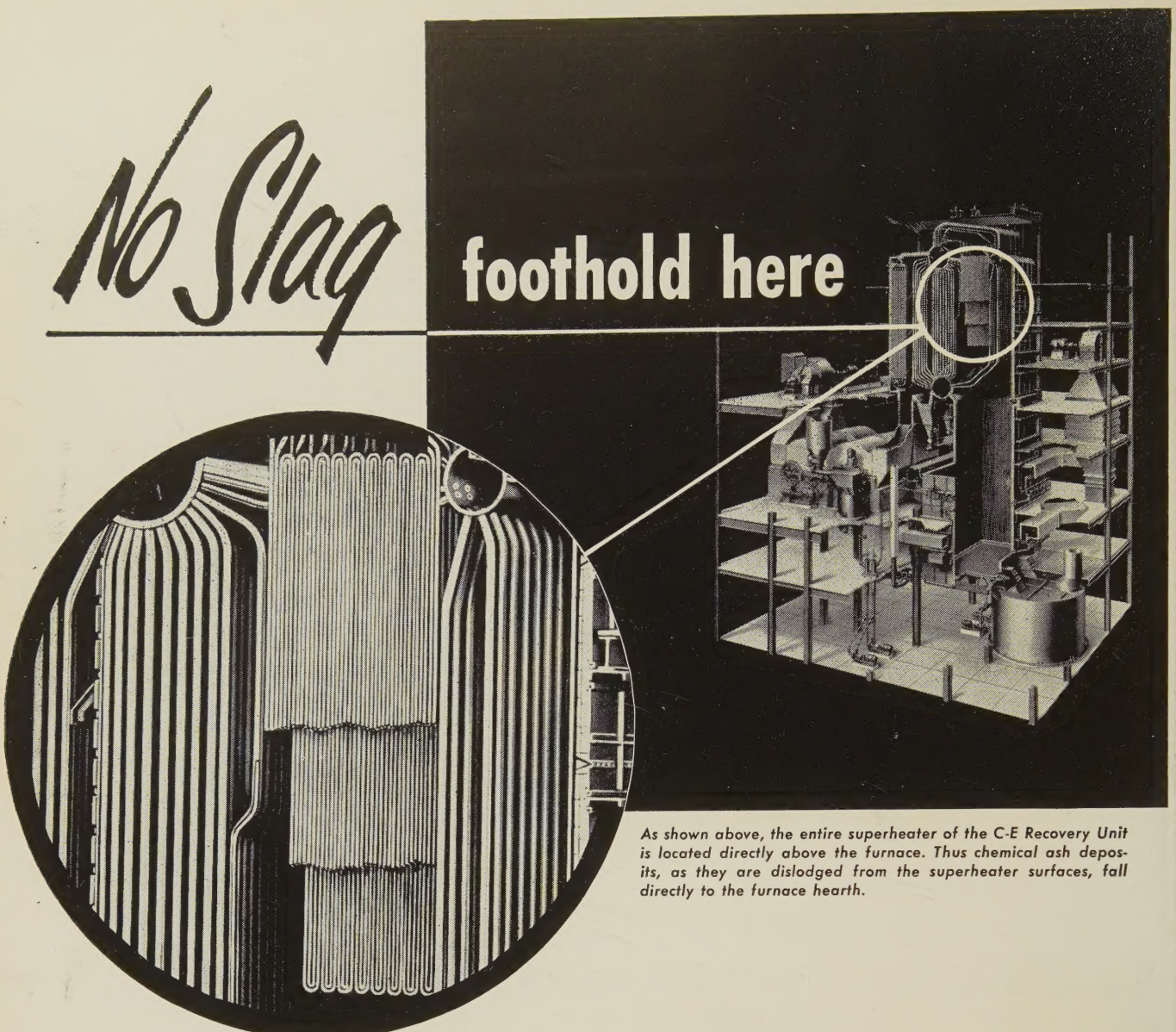
Sherbrooke Machineries Limited, Sherbrooke, Quebec,
manufacture similar equipment in Canada.

No Slag foothold here



As shown above, the entire superheater of the C-E Recovery Unit is located directly above the furnace. Thus chemical ash deposits, as they are dislodged from the superheater surfaces, fall directly to the furnace hearth.

Accumulation of slag on superheater tubes means trouble in any boiler. In a chemical recovery unit, fired with black liquor having a high percentage of low fusion temperature ash, slag accumulation can be particularly troublesome. With the conventional type superheater slag builds up and anchors itself around individual tubes, insulates them against heat transfer, blocks gas passage, increases draft loss and necessitates mechanical and manual cleaning.

The panel type superheater, found only on the C-E Recovery Unit, allows slag no such foothold. Each element — or panel — of the superheater consists of a solid wall of tangent tubes with wide spacing between panels. The space between individual tubes has been eliminated, so that any slag accumulation is confined to the wall-like surface of the elements where much of it frees itself and the rest is easily dislodged.

This panel construction channels gas flow smoothly over the superheater surfaces and slag formation is, therefore, reduced to a minimum. Furthermore, since slag cannot key-up between tubes, the action of the soot blowers is much more effective.

Developed by, and exclusive with C-E, the panel type superheater represents another significant achievement which has resulted from Combustion's consistent efforts *"to make good equipment better."*

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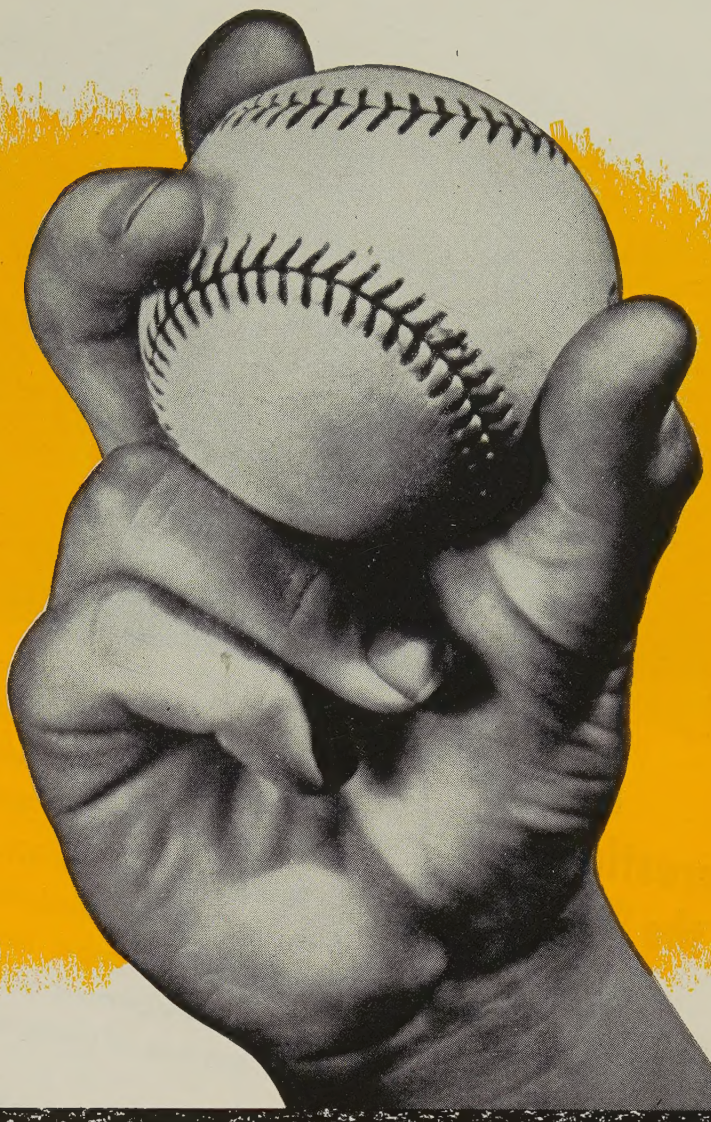

In the manufacture of fine papers, pitch control is an absolute must. The only question: what is the most effective, most economical way?

For the pitch conditions which prevail in most mills, you'll find that Nopco® 1187-X, a dehydrated naphthalene condensate readily soluble in water, tends to keep your screens, wires, and press rolls free from pitch.

You'll need only from 2 to 4 pounds of Nopco 1187-X per ton of stock. You'll find clogging of your screens and wires will be minimized, your press rolls less liable to stick. Just drop Nopco 1187-X, dry, in the beater before you add alum. Or if preferred, you can dissolve it in water and introduce it at any point before the screens. Either way, you'll control pitch and speed production.

Write today for testing sample of Nopco 1187-X, Nopco Chemical Company, 344 Water Street, Harrison, N. J.

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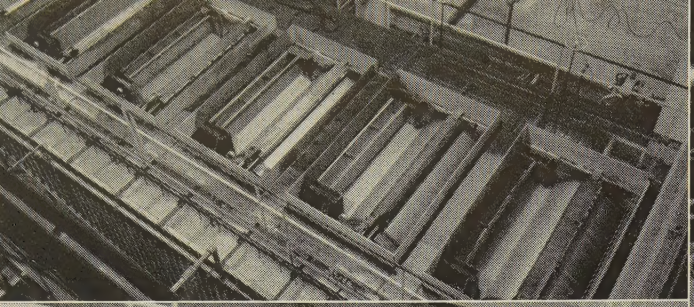

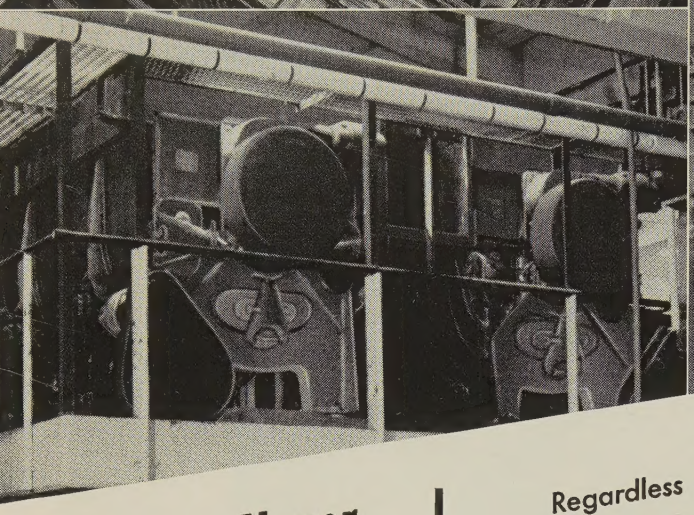

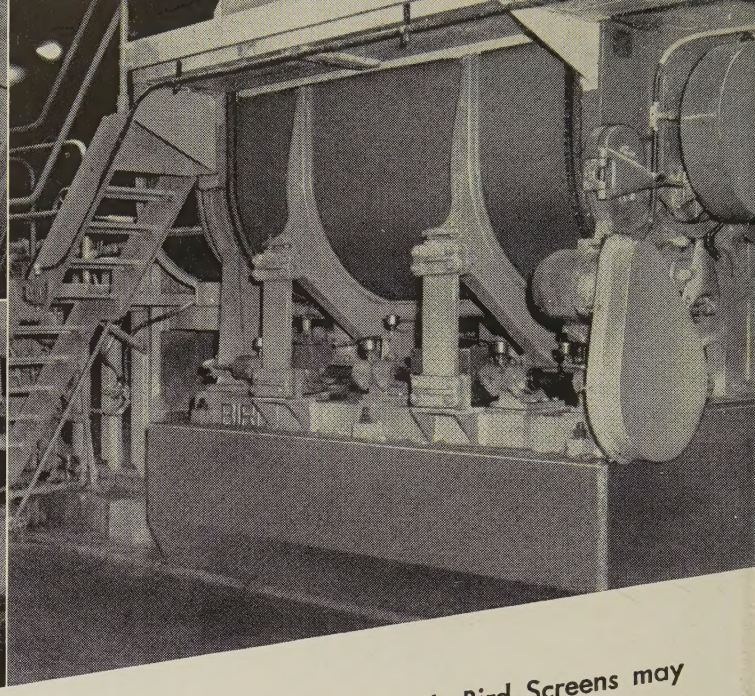

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Regardless of all other dirt removal methods Bird Screens may be depended upon to provide the one best, final barrier to dirt and to damage of delicate paper machine wires.

Bird Screens remove all dirt and foreign matter differing in size from the fibre. They comb out and individualize the fibres just before they go on the paper machine, thus improving formation. They supply a homogeneous mixture of clean fibres and water, even in weight and free of lumps, strings and slime.

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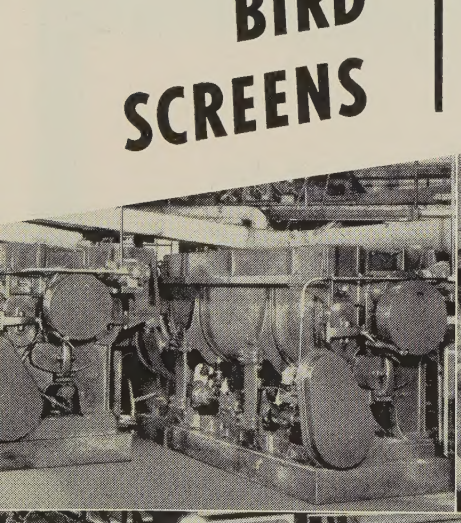

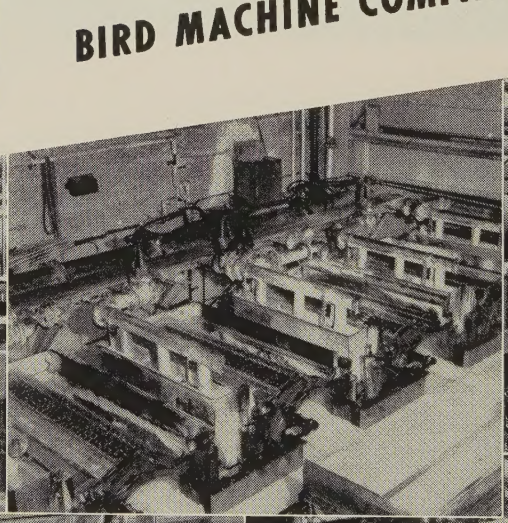

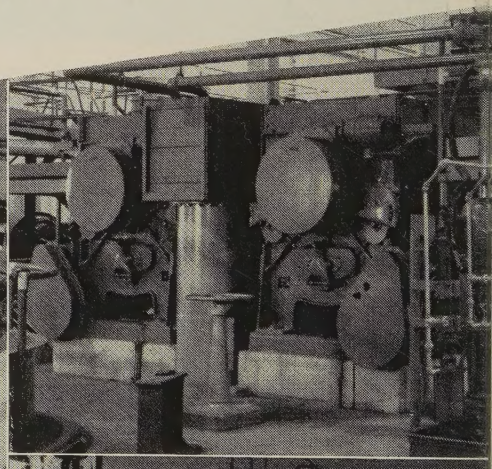

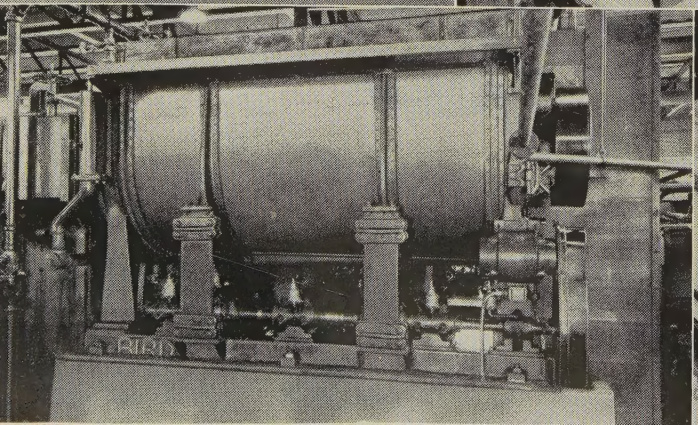

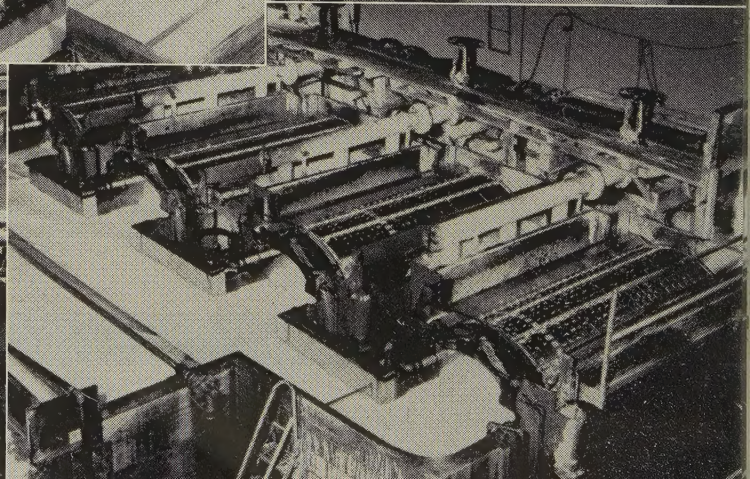

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PAPER

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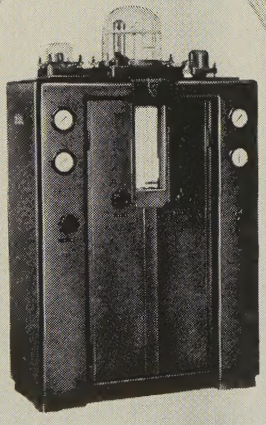
...AND COMES

CLEAN

WITH W&T CHLORINATION



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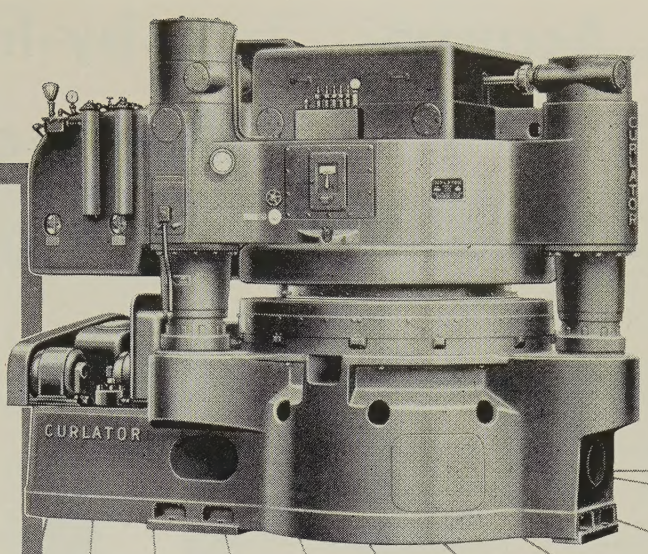

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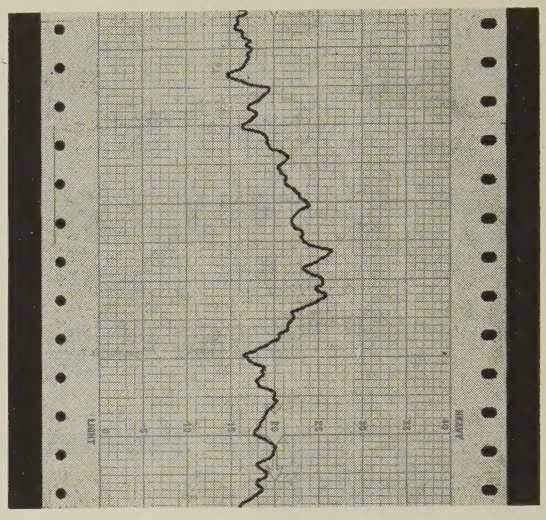

with new FOXBORO SHEET WEIGHT PROFILER

This new Foxboro development gives a *true profile* of weight variations *straight across the sheet* — no confusion with variables in the machine direction. Its *wide* open chart record (each inch represents 10" of paper) makes it easy to identify and correct faulty slice adjustments.

Mill after mill is realizing major gains in paper quality through the use of the Foxboro Sheet Weight Profiler . . . a basic production tool which has never before been available. Send today for new literature: Bulletin PD-105-2 describes the Sheet Weight Profiler; Bulletin PD-108 describes Foxboro measurement and control of the entirely independent basis weight variable in the machine direction.

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Hydroseal absorbs water rapidly and uniformly without lumping in the beaters. Its high resistance to breakdown assures strong fiber bonds and excellent starch retention. Good mullen, tensile, pick and scuff resistance result.

For those mills without facilities for beater addition, another grade, Hydroseal '5' is proving just as effective. Its ability to improve surface finish of kraft liner board and similar grades is of particular interest. Hydroseal '5' is cooked at concentrations up to 5% prior to addition. This insures rapid dispersion with the furnish and eliminates the danger of "fish eyes" in head box additions. Write for technical data.

CATIONIC STARCH OPENS NEW APPROACH TO WET END ADDITIONS

Electrochemical Affinity to Cellulose Fibers Improves Strength Properties

A new kind of wet end additive, National's Cato Starch, is modernizing wet end additions. Cato is chemically modified through substitution of cationic groups in its molecular structure. These groups are electrochemically attracted to cellulose fibers which are receptive to cationic materials. As a result, fibers retain more starch. Fiber bonding is stronger. Less additive is needed to improve the quality of a variety of papers ranging from fine writing and printing to kraft grades.

Cato is one of the more recent products of National's continuing research and development work with basic starch and starch derivatives for the paper industry. It has been used with good success for improvement of such strength factors as mullen, pick, fold and tensile with sulfite, sulfate, soda and groundwood pulp, as well as with reclaimed stock and bogus kraft. Small quantities of Cato are effective. The greatest percentage increase generally occurs with the addition of from ¼ to 1% on the weight of dry pulp. Moreover, small amounts often give very excellent retention of fillers and pigments.

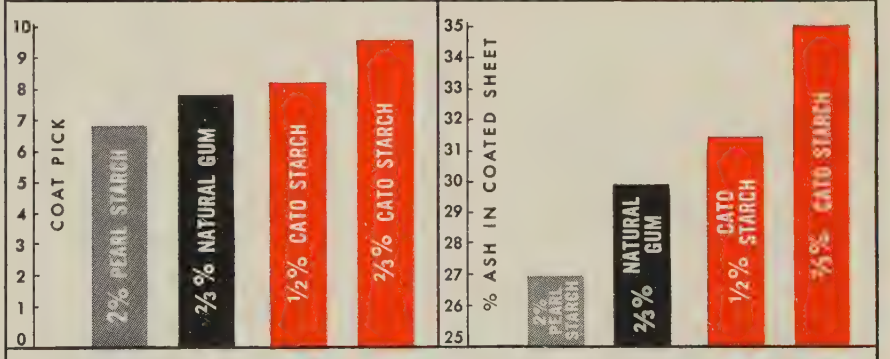
A growing list of mills is finding that Cato improves formation and reduces fuzz. Stock drains freely on the paper machine wire, often permitting faster machine speeds without impairing paper strength.

Cato is easily prepared by cooking at concentrations up to 3%. It may be added at a number of points on fourdrinier machines such as the fan pump, machine chest or headbox. On cylinder machines, Cato may be added to the stuff boxes.

For detailed information and technical assistance, contact your nearest National laboratory or sales office.

COMPARATIVE STRENGTH AND OPACITY

(in terms of coat pick and ash content)



The values above were obtained under actual mill conditions. Cato was added at the wet end. Improved formation and increased pick strength in the coating base stock allowed for improved anchorage of the coating color and a resulting increase in coat pick. Since a constant coating weight was applied to the base stock, the increase in total ash may be attributed to increased retention of fillers at the wet end.

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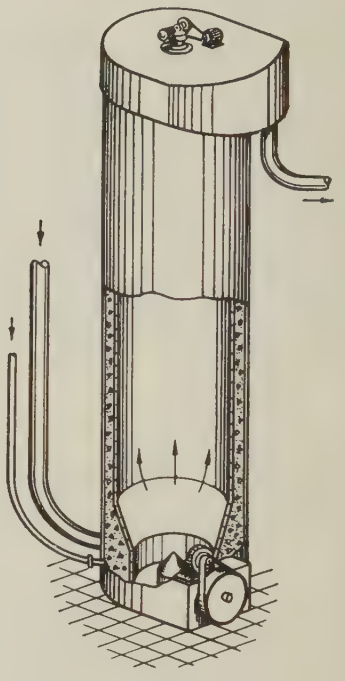
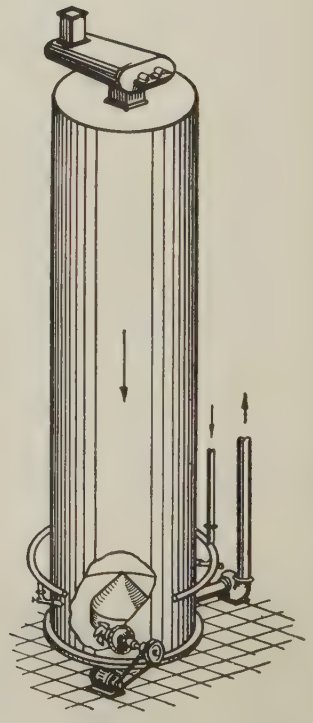
Invented by Kamyr in 1934 ►



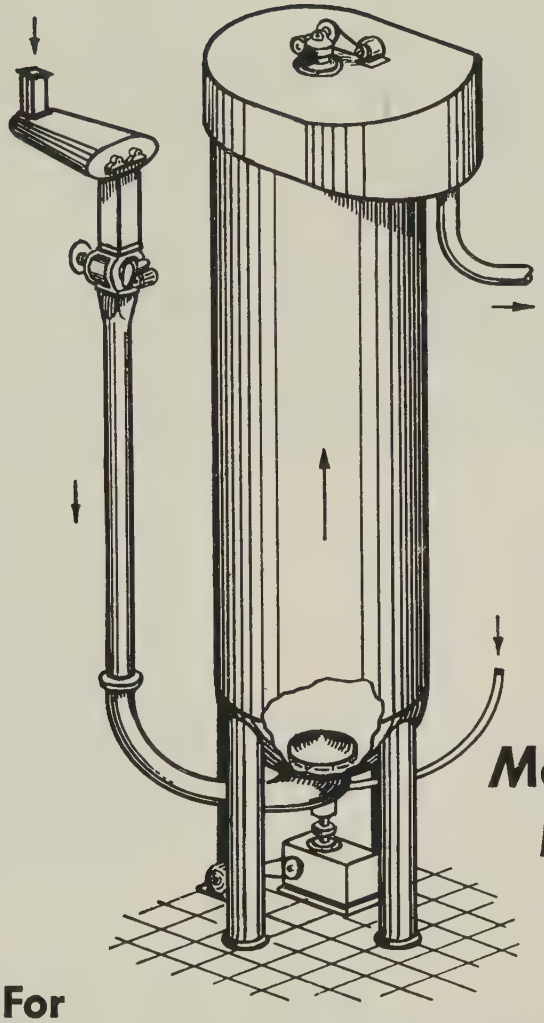
First with Today's Standard Continuous High Density Downflow Tower . . . . .

Invented by Kamyr in 1939 ►



First AGAIN with:

New Continuous High Density Upflow Tower



Invented by Kamyr in 1953

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Kamyr Equipment sold in Canada by Paper Machinery Ltd., Montreal

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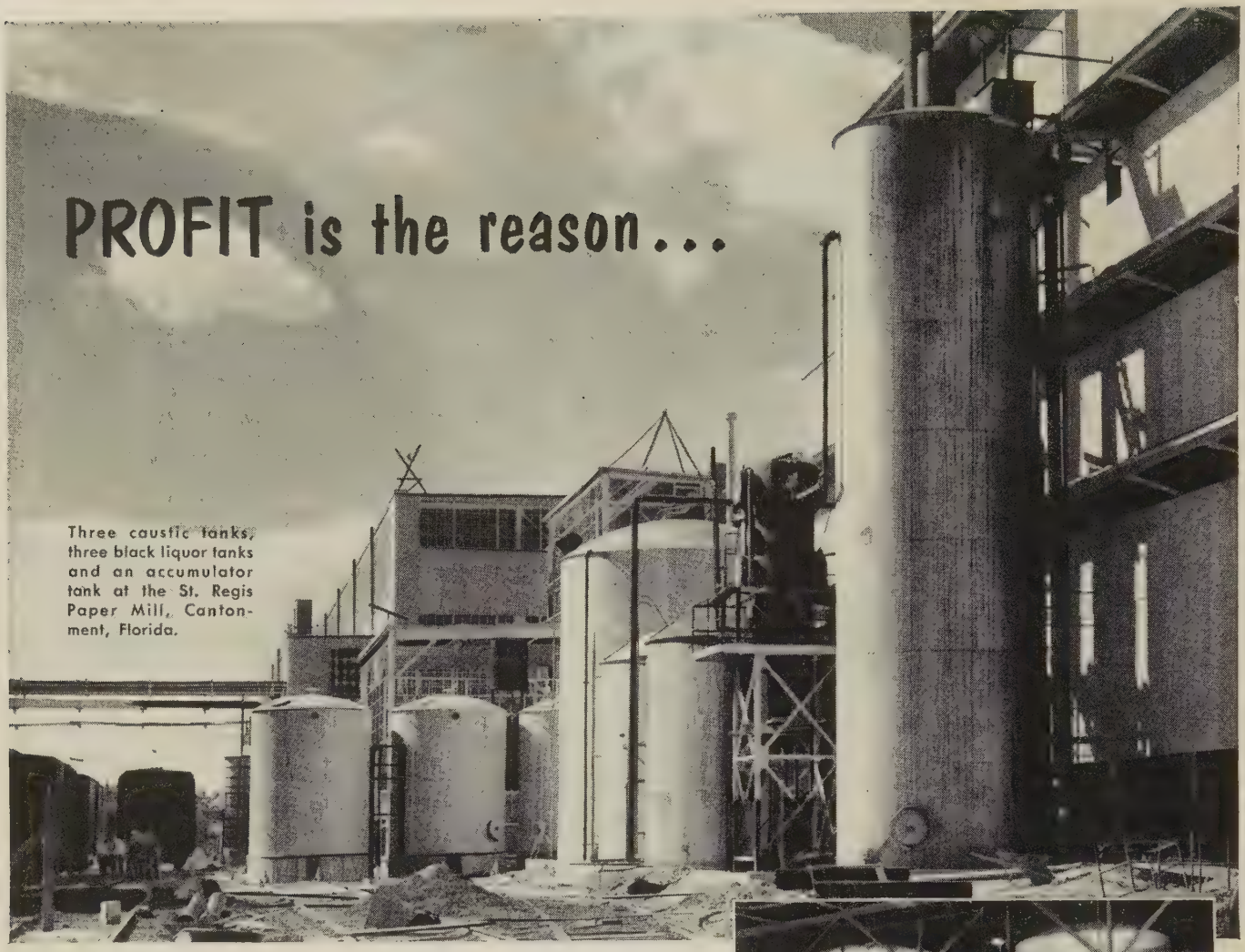

Three caustic tanks, three black liquor tanks and an accumulator tank at the St. Regis Paper Mill, Cantonment, Florida.

. . . for a paper mill's existence. To provide a mill with economical production in step with new processes calls for the best in tanks, evaporators, digesters and other steel plate structures. CB&I has the facilities to design, engineer, fabricate and erect to your requirements.

CB&I welded steel plate structures are a familiar sight throughout the paper industry . . . and for good reason . . . CB&I has built vessels and special plate work to meet the most exacting individual requirements for more than 60 years. Write our nearest office for further information. Estimates or quotations will be supplied upon request.

Above: Conkey Channel Switching Evaporator (Rosenblad Patents) operating on sulphite pulp mill waste liquors.

Conkey Sextuple Effect Evaporator, code construction throughout, operating on sulphate black liquor.

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PULP, PAPER, AND BOARD IN THE UNITED STATES

Review for 1954

W. LeROY NEUBRECH and WALLACE H. PEDERSON

PROGRESS of the pulp, paper, and board industry was more evident in 1954 than ever before in a peacetime era. Although for 1954 as a whole the Nation's aggregate production of goods and services declined only 2% below 1953, production of pulp and total paper and board not only increased over the previous year, but established a new historic record. The pulp, paper, and board industry was one of the very few major United States industries, either durable or nondurable, that recorded gains in physical output over 1953.

Approximately 1 million tons of new annual paper and board capacity was added to the industry's productive facilities in 1954, bringing total practical maximum United States capacity up to about 30 million tons by the end of last year. In 1953, the peak year of the recent expansion program, about 1.5 million tons was added to capacity. For 1955, industry estimates indicate further expansion in productive facilities of around 500,000 tons.

The margin of capacity over current levels of production in most grades is sufficient to allay concern over possible near future shortages in either a peacetime or an emergency situation. The expansions have been made in many cases for the dual purpose of possible defense needs as well as taking into account the expected growth in our industrial and business economy, which will mean a continued upward growth in demand for the products of the industry. Current productive capacity appears to be in good proportion to the present and near future anticipated domestic and foreign market requirements.

Besides adding to capacity, the year 1954 was marked by further activity in integration of operations, either through building of new facilities or by purchase or merger with existing facilities. In a number of instances, consolidations of companies were largely for the purpose of increasing diversification of grades or products. There was some evidence of the mass-grade producing mills seeking diversification into specialty grades which have been produced for many years largely by the nonintegrated mills. The continued economic existence of many of the 300-odd independent mills will depend in large measure upon modernization

W. LEROY NEUBRECH, Deputy Assistant Director, Pulp, Paper, and Paperboard—Forest Products Division, Dept. of Commerce, Washington, D. C., prepared the first section of this report.
WALLACE H. PEDERSON, Program Executive for Paper, Forest Products Division, BDSA, Dept. of Commerce, Washington, D. C., prepared the Industry Trends section.

Table I. Statistical Highlights

Item and unit	*1954*	*1953*	*Per cent change*
Pulpwood, 1000 cords			
Receipts	28,597	27,867	+2.6
Consumption	29,201	28,141	+3.8
Inventories	5,058	5,639	−10.3
Wood pulp (total), 1000 short tons			
Production	18,341	17,537	+4.6
Imports	2,050	2,158	−5.0
Exports	442	162	+173.4
New supply[a]	19,948	19,533	+2.1
Consumption, total	19,796	19,480	+1.6
Paper and board	19,034	18,681	+1.9
Nonpaper	762	799	−4.6
Inventories	759	738	+2.8
Pulp, paper, and board mills	674	655	+2.9
Nonpaper mills	85	83	+2.4
Market wood pulp (at paper and board mills), 1000 short tons			
Receipts	2,447	2,490	−1.7
Consumption	2,422	2,500	−3.1
Inventories	395	380	+3.9
Market wood pulp (at nonpaper mills), 1000 short tons			
Receipts	763	778	−1.9
Consumption	762	799	−4.6
Inventories	85	83	+2.4
Waste paper, 1000 short tons			
Receipts	8,025	8,427	−4.8
Consumption	8,064	8,531	−5.5
Inventories	452	479	−5.6
Paper and board production, total, 1000 short tons	26,657	26,528	+0.5
Paper	11,615	11,406	+1.8
Paperboard	12,047	12,275	−1.9
Wet machine	132	152	−13.2
Construction paper and board	2,863	2,695	+6.2
Wholesale paper and paper products, 1,000,000 dollars			
Sales	2,681	2,587	+3.6
Inventories	249	266	−6.4

[a] New supply equals production plus imports minus exports.
Source: Prepared by the Forest Products Division, Business and Defense Services Administration, Department of Commerce, based on data from the Bureau of Census and the Office of Business Economics, Department of Commerce.

Table II. Pulp, Paper, and Board Highlights

Item	*Unit, millions of*	*1954*	*1953*	*1952*	*1951*	*1950*	*1949*	*1948*	*1947*
Pulpwood consumption	Cords	29.2	28.1	26.5	26.5	23.6	19.9	21.2	19.7
Wood pulp production	Tons	18.3	17.5	16.5	16.5	14.8	12.2	12.9	11.9
Wood pulp consumption[a]	Tons	19.0	18.7	17.3	17.7	16.5	13.6	14.4	13.3
Waste paper consumption[a]	Tons	8.1	8.5	7.9	9.1	3.0	6.6	7.6	8.0
Paper and board production	Tons	26.7	26.5	24.4	26.0	24.4	20.3	21.9	21.1
Wood pulp imports	Tons	2.1	2.2	1.9	2.4	2.4	1.8	2.2	2.3
Newsprint imports	Tons	5.0	5.0	5.0	5.0	4.9	4.6	4.4	4.0

[a] In manufacture of paper and board only.
Source: Bureau of the Census, U. S. Department of Commerce.

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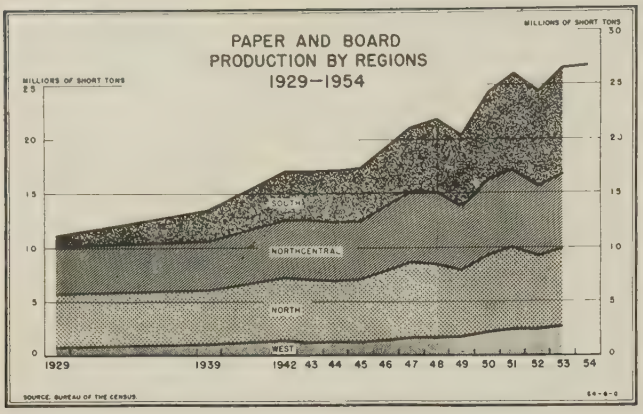


of plant facilities. A few splendid examples of progressive management in this direction were manifest in 1954.

One of the primary general objectives of the consolidations in operations was for the purpose of efficiencies in operation to try to counter-balance growing costs in capital investment, labor, and transportation. Being a large user of cumbersome raw materials, such as pulpwood and waste paper, much concern is evident in devising ways and means of reducing handling costs. Going way back to the growing timber, mechanization is the keyword for forestry practices, logging, utilization of waste wood through mechanical and hydraulic barking devices, new methods of handling wood in pulp mill storage yards, and many other innovations. Streamlining of pulp, paper, and board mill operations, speeding up machines, new wider machines, and many other improved manufacturing techniques, including lowering costs in finishing room operations, were evident in 1954 and will continue in the years ahead. Marketing of former mill waste by-products is gaining gradually. Rising transportation costs have meant the development of ways and means to cut down on skid or heavy boxed shipments, especially on orders for smaller quantities. Integrating facilities at one location has meant savings in labor and shipping costs of materials.

Reducing distribution costs to ultimate consumers is a factor of great importance to the mills as well as to the wholesale merchants. The merchants have also encountered the 1954 trend toward smaller orders at more frequent intervals and demands for better services, which has meant higher operating costs. Hundreds of paper merchants have remodeled their warehouses and acquired new mechanical handling facilities to cut down on overhead costs.

The field of general commodity distribution, especially at retail levels, appears to be the "stage setting" for the next era of major change. The national growth in the super self-service grocery and drug stores during the past decade would suggest a similar pattern in many other types of retail merchandise. The individual sanitary packaging of foods and drugs, largely in paper or paperboard, made possible the serve-yourself type of operation in groceries, drugs, and allied lines. What will a few more years mean in thousands of other items, such as men's ties, shirts, or socks; women's hose, underwear, handbags, etc.; household necessities, hardware, etc.? Should self-service retailing spread to the various items on a national basis,

Table III. Total Value of Sales of the Pulp, Board, and Products Manufacturing Industry

Year	Millions of dollars	Year	Millions of dollars
1939	1785	1947	5764
1940	2064	1948	6060
1941	2836	1949	5448
1942	2965	1950	6976
1943	3389	1951	8477
1944	3629	1952	7979
1945	3725	1953[a]	8704
1946	4469	1954[b]	8738

[a] Revised. [b] Preliminary.
Source: Office of Business Economics, Department of Commerce. The estimated dollar total of sales represents receipts of all operators of pulp, paper, paperboard, and product manufacturing companies. The figures include data for both corporate and noncorporate businesses but are comparable to the sales data for corporations in Statistics of income published by the Bureau of Internal Revenue.

Table IV. Total United States Imports and Exports Paper Base Stocks, Paper, and Manufacturers (In millions of dollars)

Year	Imports	Exports	Year	Imports	Exports
1939	215	40	1950	746	107
1945	298	102	1951	958	231
1946	419	116	1952	925	193
1947	657	173	1953	933	153
1948	754	139	1954[a]	925	228
1949	666	113			

[a] Preliminary.
Source: Bureau of the Census, U. S. Department of Commerce.

Table V. Annual Value of Sales of United States Wholesale Distributors of Paper and Its Products, 1939–54

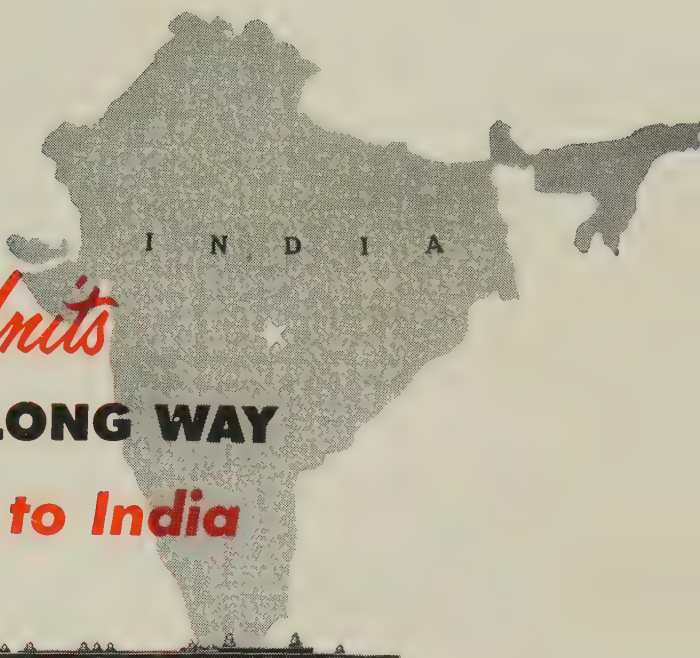
Year	Millions of dollars	Year	Millions of dollars
1939	575	1947	1828
1940	608	1948	1902
1941	739	1949	1735
1942	695	1950	2266
1943	823	1951	2678
1944	878	1952	2461
1945	909	1953[a]	2587
1946	1275	1954[b]	2681

[a] Revised. [b] Preliminary.
Source: Office of Business Economics, Department of Commerce.

Table VI. Monthly Value of Sales of United States Wholesale Distributors of Paper and Its Products, 1947–54
(Millions of dollars)

Month	1954[a]	1953	1952	1951	1950	1949	1948	1947
January	223	210	213	258	158	148	163	135
February	201	192	198	223	152	136	152	123
March	217	220	207	243	166	148	159	134
April	209	216	208	222	160	137	157	144
May	200	205	198	236	169	131	151	146
June	213	200	185	226	185	139	161	151
July	210	216	185	198	175	125	144	150
August	245	233	201	232	219	152	163	154
September	238	235	221	202	212	152	166	176
October	240	232	234	242	231	154	169	188
November	247	216	203	215	224	155	162	163
December	238	212	208	181	215	146	155	164
Total	2681	2587	2461	2678	2266	1723	1902	1828

[a] Preliminary.
Source: Office of Business Economics, U. S. Department of Commerce.



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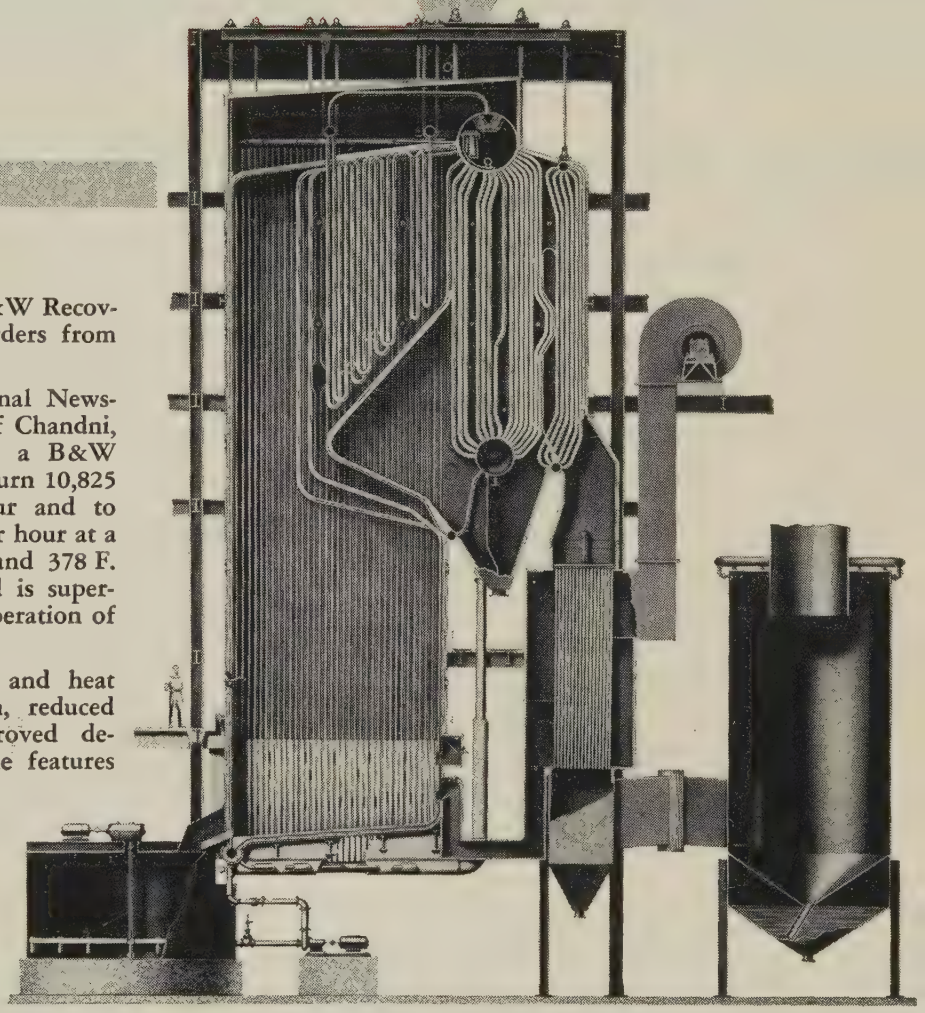

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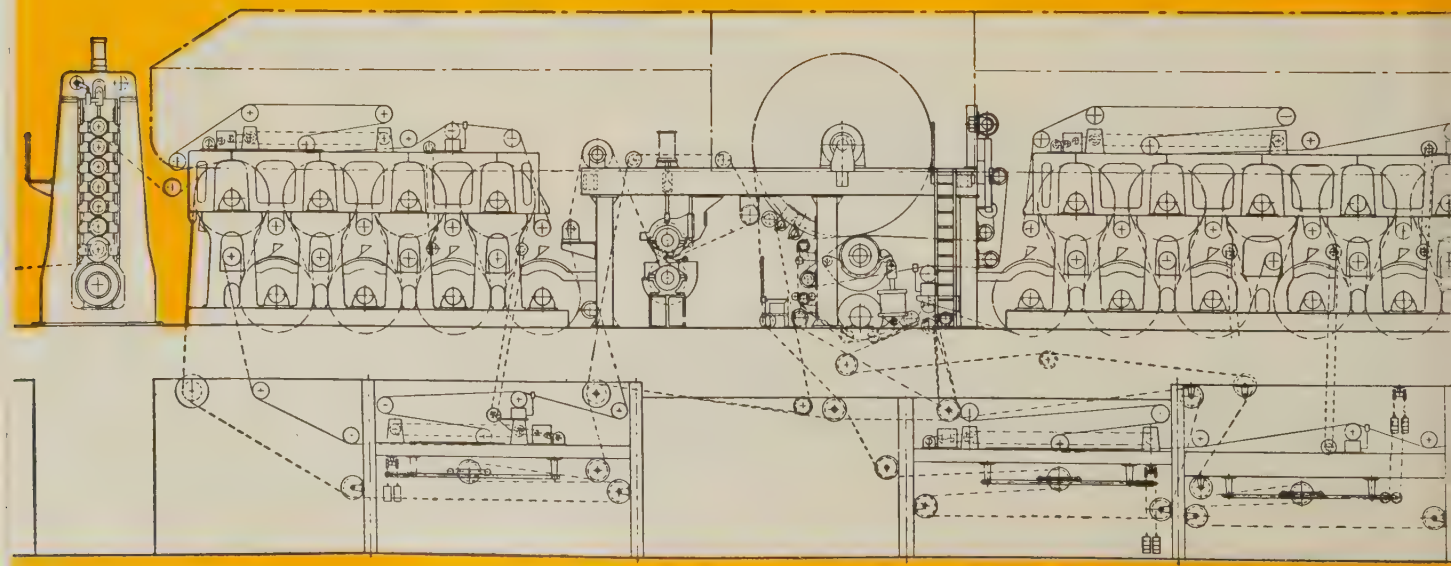
Fourdrinier Part: Suitable for wire 196"x94'-2", with dual breast roll arrangement. Table rolls are rubber covered, wire return rolls are stainless steel. Suction couch roll is 44" dia., with 6" to 10" adjustable suction box.

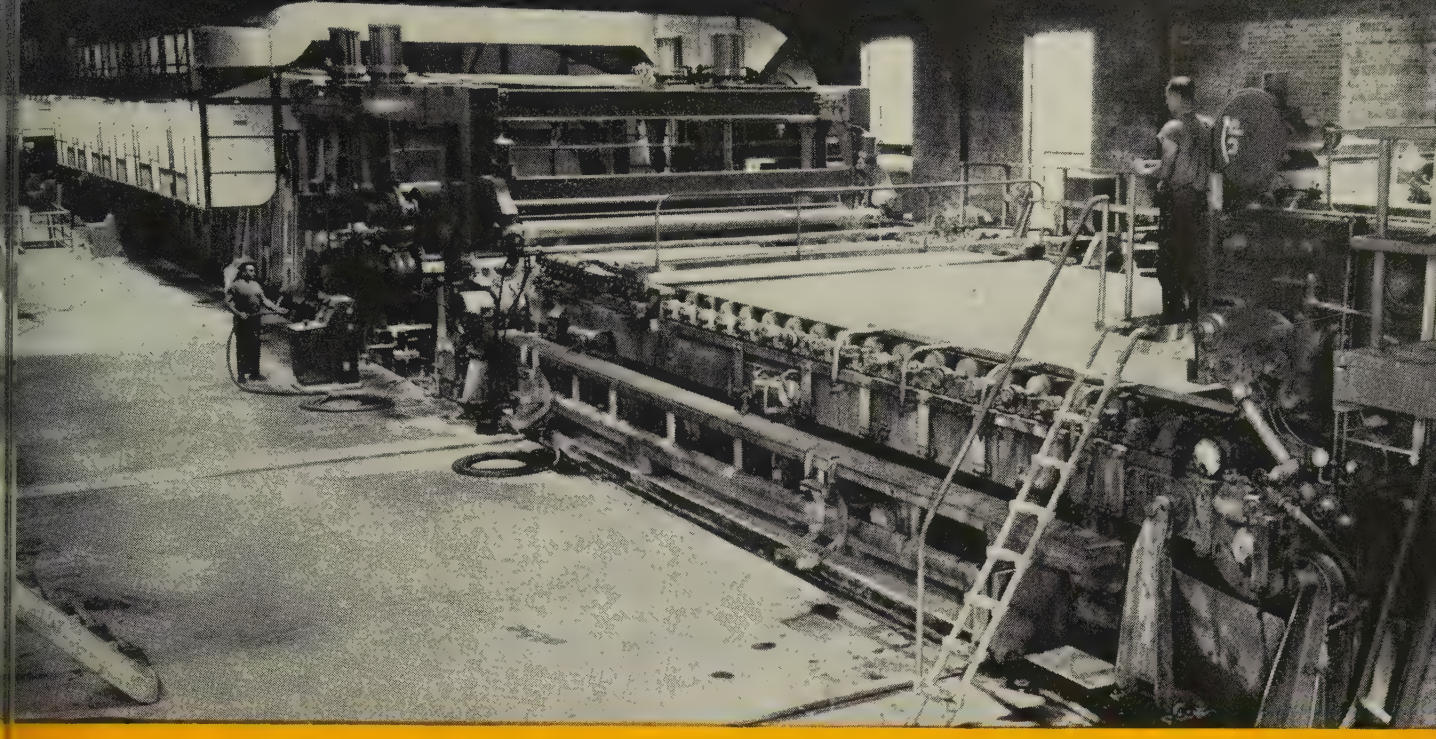
Press Part: Simplex type with two 36" dia. suction press rolls, the first with a 4" suction box and the second with a 4" to 8" adjustable box. Felt stretchers are operated by air motors.

Dry Part: Pre-dryer consists of 23 paper dryers and 8 felt dryers, each 60" in diameter, and one 36" dia. transfer dryer, all constructed for 75 pounds steam pressure. Yankee dryer is 12' in diameter, constructed for 125 pounds steam pressure, with two 32" pressure rolls. Size press is followed by steam-heated 24" set roll and Mt. Hope expander roll.

After-dryer section has eight 60" dia. paper dryers constructed for 125 pounds steam pressure.

8-roll Calender stack with non-deflecting bottom roll and Puseyjones horizontal track Pope-type reel—provided at the finishing end. The machine is driven by a Reliance sectional generator type drive with a range from 500 to 2,000 f.p.m.





. . . at FRASER

In June, 1954, Fraser Paper, Ltd., dismantled a 26-year-old Puseyjones machine at their Madawaska, Maine, mill. In its place, a new one, designed and constructed to operate up to a speed of 2,000 feet per minute, was installed. Width of the new machine required widening of the foundation.

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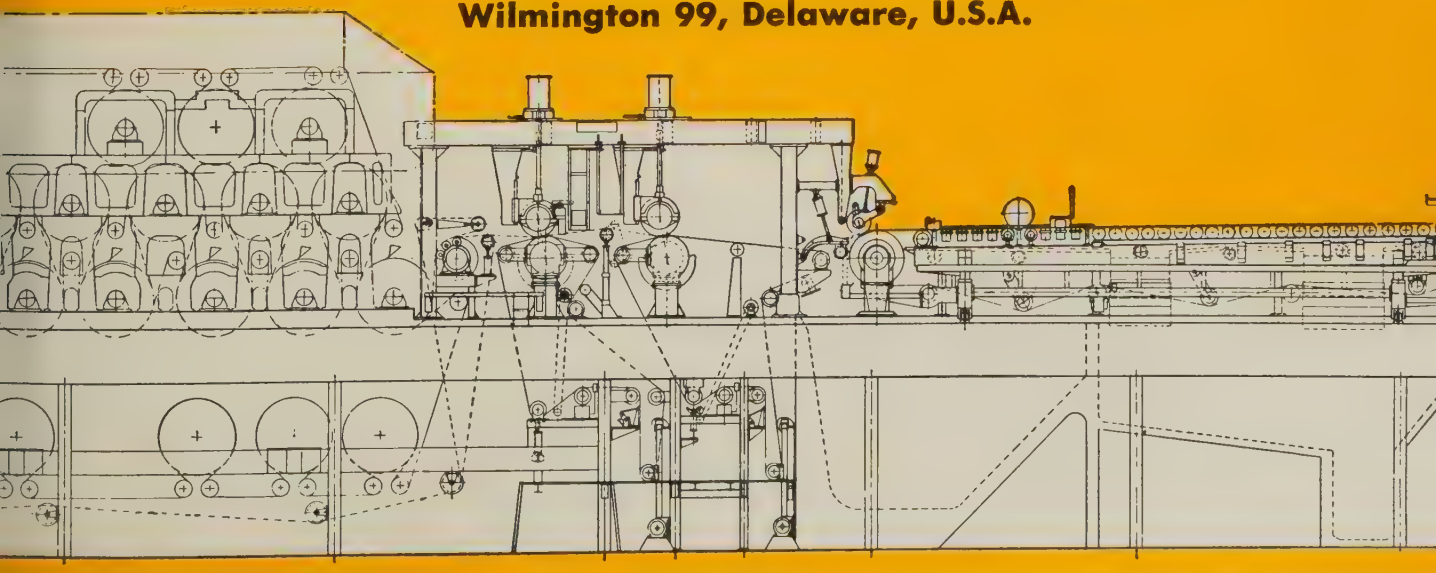

Table VII. Pulpwood—United States Annual Receipts, Imports, Consumption, and Inventories, 1944–54
(1000 standard cords—roughwood basis)

Item	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944
Receipts, total	28,597	27,867	27,375	27,778	22,546	19,266	22,333	20,619	18,978	16,982	16,999
Domestic	26,973	26,319	25,065	25,128	20,712	17,619	20,026	18,542	16,932	15,253	15,349
Imported	1,624	1,548	2,310	2,650	1,834	1,647	2,307	2,077	1,996	1,729	1,650
Northeast, total	3,834	3,832	4,549	4,723	3,295	3,275	4,039	4,135	3,650	3,389	3,039
Domestic	2,739	2,807	3,250	3,137	2,235	2,366	2,666	2,970	2,508	2,311	1,976
Imported[b]	1,095	1,025	1,300	1,586	1,060	909	1,373	1,165	1,142	1,078	1,063
Appalachian, total	1,904	1,868	1,630	1,960	1,705	1,544	1,784	1,623	1,716	1,388	1,482
Domestic	1,904	1,868	1,630	1,960	1,705	1,544	1,763	1,610	1,684	1,365	1,472
Imported[b]	..	..	..	..	..	..	21	13	32	23	10
Lake States, total	2,973	2,762	3,228	3,425	2,472	2,149	3,031	2,900	2,919	2,456	2,638
Domestic	2,444	2,239	2,459	2,622	1,985	1,619	2,344	2,154	2,239	1,954	2,175
Imported	529	523	768	803	487	530	687	746	680	502	463
South, total	14,962	14,959	13,382	12,844	11,543	9,060	9,997	8,227	7,909	7,153	7,090
Domestic	14,962	14,959	13,382	12,844	11,543	9,060	9,997	8,227	7,909	7,153	7,090
West, total	4,924	4,446	4,586	4,826	3,531	3,238	3,482	3,734	2,784	2,596	2,750
Domestic	4,924	4,446	4,344	4,565	3,244	3,030	3,256	3,581	2,642	2,470	2,636
Imported[b]	..	..	241	261	287	208	226	153	142	126	114
Consumption, total	29,201	28,141	26,476	26,522	23,627	19,945	21,189	19,714	17,818	16,913	16,758
Northeast	3,829	3,848	4,047	4,280	3,704	3,397	3,814	3,740	3,466	3,245	3,159
Appalachian	1,976	1,821	1,673	1,859	1,796	1,614	1,767	1,684	1,501	1,444	1,490
Lake States	2,957	3,036	2,925	3,039	2,825	2,461	2,821	2,724	2,554	2,544	2,474
South	15,014	14,752	13,320	12,854	11,480	9,255	9,443	8,395	7,516	7,208	7,153
West	5,425	4,684	4,511	4,490	3,822	3,218	3,344	3,171	2,781	2,472	2,482
Inventories, total	5,058	5,639	5,929	5,072	3,815	4,905	5,622	4,566	3,780	2,626	2,819
Northeast	1,335	1,665	1,937	1,483	1,051	1,520	1,644	1,442	1,063	869	700
Appalachian	305	369	323	367	249	332	397	372	422	206	279
Lake States	1,411	1,418	1,693	1,380	986	1,343	1,674	1,487	1,350	986	1,088
South	1,048	1,089	856	772	753	670	828	291	526	145	218
West	959	1,098	1,120	1,070	776	1,040	1,079	974	419	420	534

[a] Preliminary. [b] Imports to Appalachian and West regions included in Northeast to avoid disclosure of individual company data.
Note: Detail may not add to totals because of rounding.
Sources: Prepared by the Forest Products Division—Business and Defense Services Administration. Data covering 1944, Forest Products Bureau, War Production Board; data covering 1945–54, inclusive—Bureau of the Census, U. S. Department of Commerce.

Table VIII. Wood Pulp—United States Annual Imports and Exports, 1943–54
(1000 short tons)

Item	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944	1943
Imports, total	2050	2158	1937	2361	2385	1763	2176	2322	1805	1754	1072	1306
Bleached sulphite: Rayon and special chemical grades	230	256	223	231	239	154	235	249	202	146	133	129
Bleached sulphite: Other	288	332	277	349	402	331	323	288	223	242	188	231
Unbleached sulphite	339	381	432	557	529	392	675	732	618	657	399	519
Bleached sulphate	637	591	519	522	450	392	278	239	80	72	47	48
Unbleached sulphate	270	292	208	336	440	249	336	470	398	380	99	105
Soda	38	35	28	33	34	27	25	21	20	21	16	20
Chemical screenings	[c]	7	4	10	5	3	8	10	9	7	7	11
Bleached mechanical	63	65	34	18	20	1	..	..	1	1	[b]	..
Unbleached mechanical	174	194	208	300	260	208	291	309	249	222	177	236
Mechanical screenings	11	4	4	5	6	6	5	5	6	5	5	6
Exports, total	442	162	212	200	96	122	94	130	39	135	218	301
Bleached sulphite: Rayon and special chemical grades	153	69	65	31	28	25	18	11	8	13	11	23
Bleached sulphite: Other	58	18	24	44	18	20	13	44	7	17	38	45
Unbleached sulphite	51	31	35	44	33	39	54	54	17	27	46	90
Bleached sulphate	99	13	12	9	5	9	1	2	1	6	7	16
Unbleached sulphate	75	29	75	69	9	27	6	17	5	60	106	121
Soda	6	2	1	1	[b]	[b]	1	1	[b]	11	11	5
Screenings and other wood pulp			..	2	2	1	1	2	1	1	[b]	1

[a] Preliminary. [b] Less than 500 tons. [c] Included with mechanical screenings.
Note: Detail may not add to total because of rounding.
Source: Bureau of the Census, U. S. Department of Commerce.

Table IX. Total United States Annual Wood Pulp Imports All Grades—by Major Countries of Origin
(1000 short tons)

Country	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945
Total	2050	2158	1937	2361	2385	1763	2176	2322	1805	1754
Canada[b]	1678	1614	1578	1877	1717	1314	1601	1529	1245	1082
Sweden	224	336	190	258	398	266	385	555	445	672
Finland	133	160	145	183	206	149	176	224	115	..
Norway	15	37	21	36	29	29	13	10	..	..
All other	..	11	3	7	35	5	2	5	..	..

[a] Preliminary. [b] Includes Newfoundland.
Note: Detail may not add to totals because of rounding.
Source: Prepared by the Forest Products Division—Business and Defense Services Administration, based upon data from the Bureau of the Census, U. S. Department of Commerce.

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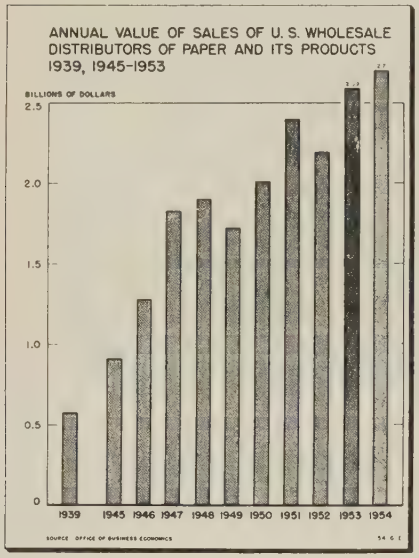
the per capita consumption of paper and board should rise proportionately.

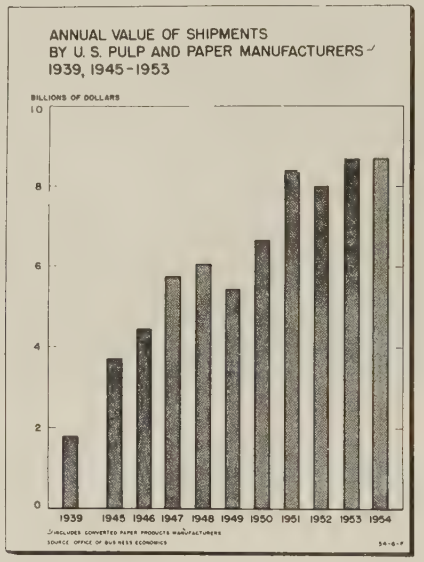
From a marketing point of view, more companies have been enlarging their operations to cover larger areas of sales distribution, in many cases national, and in fewer cases into selected foreign countries. Perhaps 1954 will go down in history as the first year of major interest of the industry into foreign markets, not alone for their products produced in the United States, but also the establishing of branch plants in foreign lands.

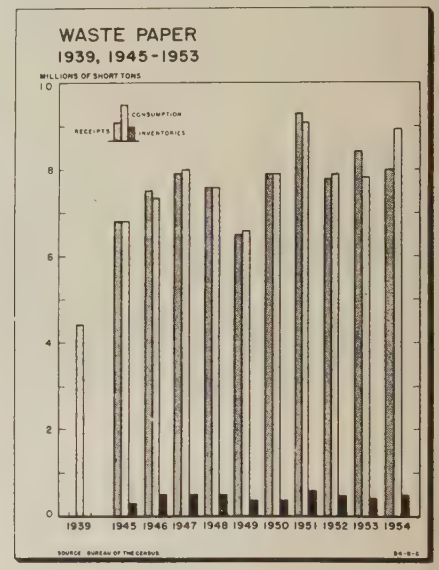
United States production of paper and board in 1954 totaled 26.7 million tons compared with 26.5 million in 1953, 24.4 million in 1952, and 26.0 million in 1951. Supplementing United States 1954 production of 26.7 million tons of paper and board were imports of 5.2 million tons, resulting in a new supply available for distribution of 31.8 million tons. Subtracting United States exports in 1954 of 590 thousand tons left a balance of 31.2 million tons, which apparently went into actual consumption during the year. Inventory levels of paper and board at mills, converters, and wholesale merchants remained relatively steady throughout 1954. Total United States apparent consumption of paper and board in 1954 was slightly under the previous year. In 1953 apparent consumption was 31.4 million tons as against approximately 30.0 million tons in both 1952 and 1951.

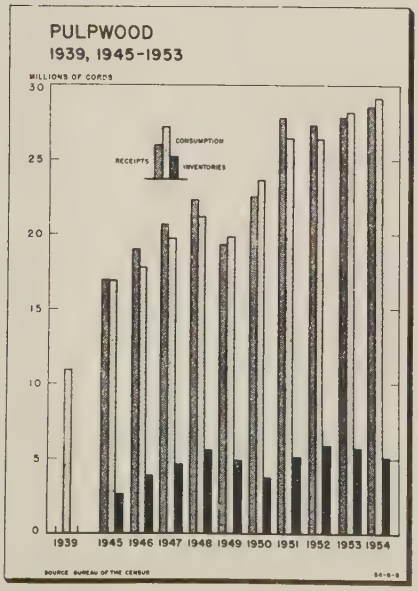
United States production of newsprint paper in 1954, totaling 1,192,000 tons, was the largest domestic output since 1931. Domestic output of newsprint paper has been rising steadily since 1946 following the low point of 1944, when only 721,000 tons were produced. There are now three large newsprint mills located in the southern states, one in Texas, one in Alabama, and one in Tennessee, the latter having started production in 1954. These mills, coupled with expansion of other existing mills, have added materially to domestic production capacity. A large newsprint mill in Maine started new facilities in 1954 through the utilization of hardwoods by the chemiground wood process. Another large domestic pulp and paper company has announced plans to construct a new newsprint mill in one of the southern states.

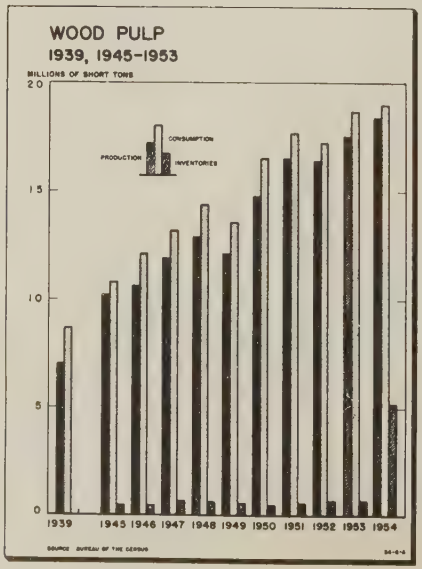
United States apparent consumption of newsprint in

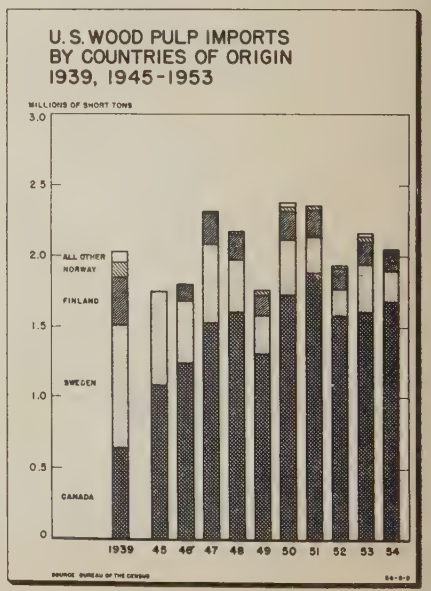












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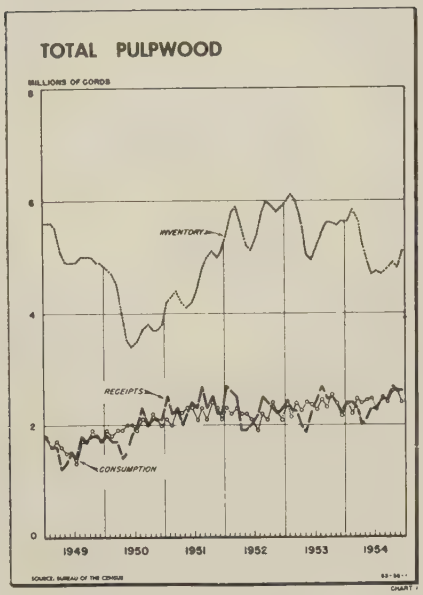
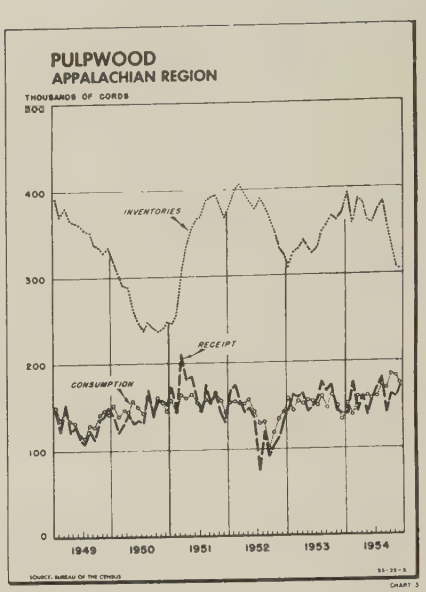

TOTAL PULPWOOD
BILLIONS OF CORDS
INVENTORY
RECEIPTS
CONSUMPTION
1949
1950
1951
1952
1953
1954


PULPWOOD
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THOUSANDS OF CORDS
INVENTORIES
RECEIPT
CONSUMPTION
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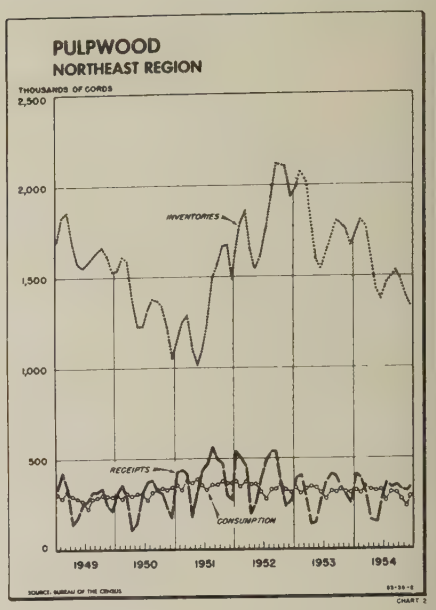
1954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NORTHEAST REGION
THOUSANDS OF CORDS
INVENTORIES
RECEIPTS
CONSUMPTION
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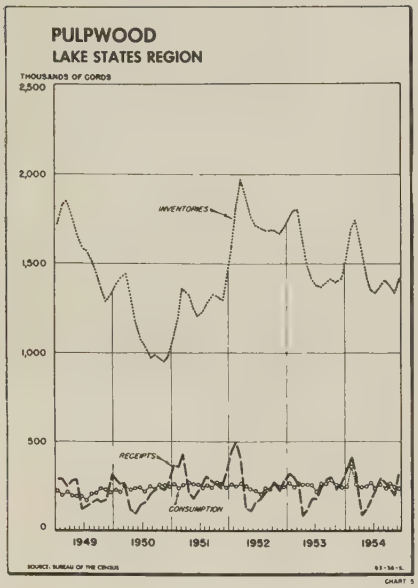
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LAKE STATES REGION
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INVENTORIES
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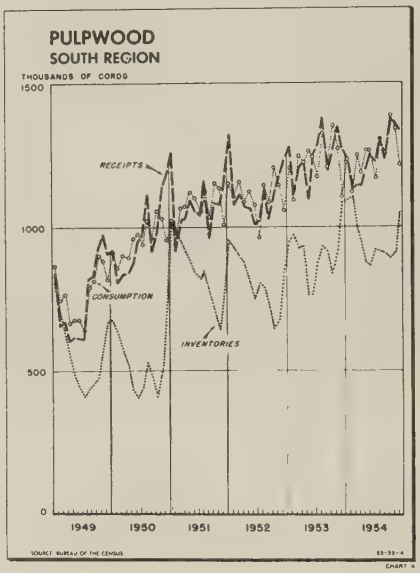
PULPWOOD
SOUTH REGION
THOUSANDS OF CORDS
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CONSUMPTION
INVENTORIES
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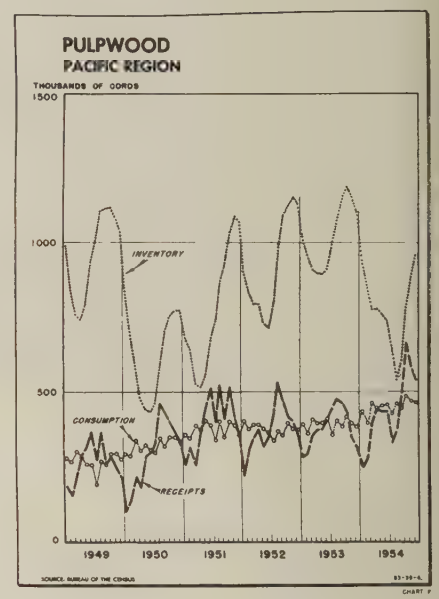
PULPWOOD
PACIFIC REGION
THOUSANDS OF CORDS
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CONSUMPTION
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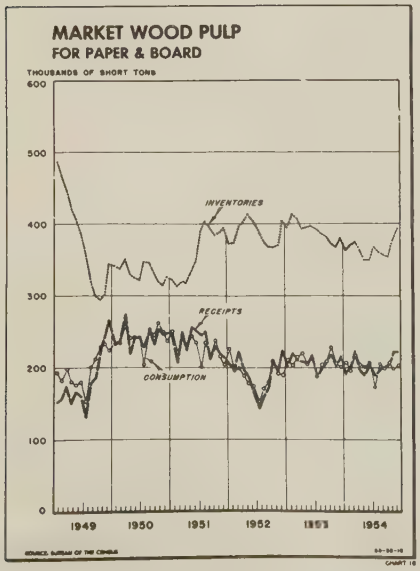
MARKET WOOD PULP
FOR PAPER & BOARD
THOUSANDS OF SHORT TONS
INVENTORIES
RECEIPTS
CONSUMPTION
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1950
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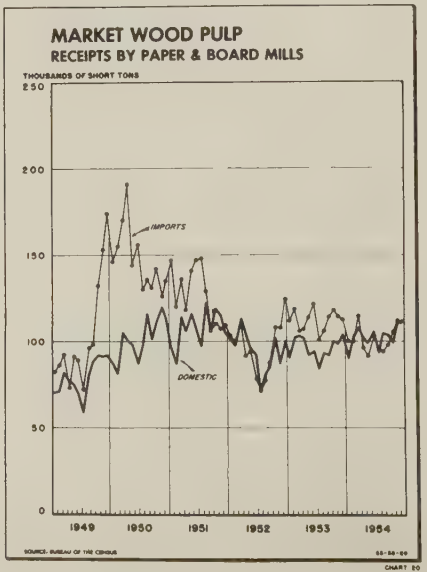
1952
1953
1954


MARKET WOOD PULP
RECEIPTS BY PAPER & BOARD MILLS
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IMPORTS
DOMESTIC
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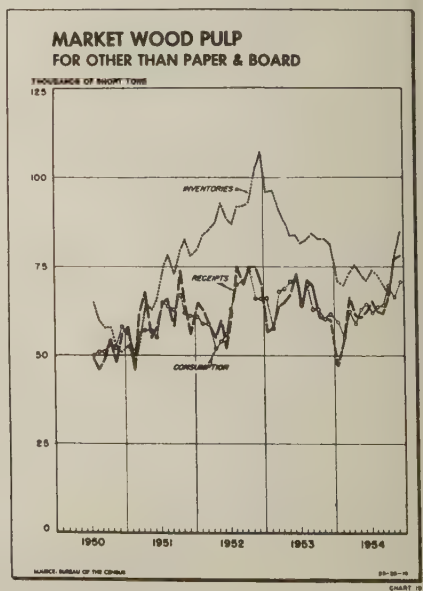
MARKET WOOD PULP
FOR OTHER THAN PAPER & BOARD
THOUSANDS OF SHORT TONS
INVENTORIES
RECEIPTS
CONSUMPTION
1950
1951
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1953
1954

Mersize RM Dry meets Franconia's high sizing standards for offset papers!

From Franconia Paper Co., Lincoln, N.H., comes more proof that America's top papermakers choose Mersize RM Dry for uniform hard sizing of highest quality . . .

At regular intervals during the hour, Franconia checks the quality of their offset papers. With a special hot-ink sizing test, developed by Franconia technicians, offset papers are constantly tested to insure that sizing has provided sufficient water resistance. *Mersize RM Dry meets this test for highest quality.*

If you use dry size, discover for yourself how Mersize RM Dry's dependable quality can increase the efficiency of your operation. Beater-room men appreciate low-dusting Mersize RM Dry—less irritating, less trouble to handle. Its low foam index helps eliminate countless production troubles.

Mersize RM Dry improves product quality because its very light color, resistant to darkening with age, produces high-brightness paper comparable to the lightest rosin size.

For full information on Mersize RM Dry, write Organic Chemicals Division, MONSANTO CHEMICAL COMPANY, Box 478 M-3, St. Louis 1, Missouri.

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Other Members of Monsanto's Complete Line of Fortified Sizes

Mersize CD-2
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Complete fortified paste size
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Complete fortified paste size

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Table X. Wood Pulp—United States Annual Production and Domestic Consumption in Paper and Board Manufacture
(1000 short tons)

Item	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944
Production, total	18,341	17,537	16,473	16,524	14,849	12,207	12,872	11,946	10,607	10,167	10,108
Special alpha and dissolving	791	677	706	616	479	374	[b]	[b]	[b]	[b]	[b]
Sulphite, total[c]	2,383	2,323	2,365	2,525	2,370	2,162	2,811	2,796	2,476	2,360	2,386
Bleached[c]	1,801	1,729	1,692	1,761	1,629	1,455	1,909	1,902	1,692	1,544	1,523
Unbleached	582	594	673	764	741	707	902	894	784	816	863
Sulphate, total	9,808	9,445	8,569	8,572	7,502	5,977	6,014	5,357	4,588	4,472	4,549
Bleached	2,684	2,389	2,083	1,899	1,433	1,118	1,040	909	750	705	665
Semibleached	327	303	275	294	360	264	225	193	152	149	144
Unbleached	6,797	6,753	6,211	6,379	5,709	4,595	4,749	4,255	3,686	3,618	3,740
Soda	432	427	425	446	522	492	510	492	476	430	413
Groundwood	2,428	2,343	2,380	2,474	2,216	1,961	2,175	2,050	1,897	1,696	1,639
Defibrated, exploded, etc.	1,203	1,153	1,059	945	935	604				691	663
Semichemical	1,126	1,029	829	797	686	506	1,362	1,252	1,169	519	459
Screenings, damaged, etc.	170	140	140	150	140	130					
Consumption, total	19,034	18,681	17,286	17,737	16,509	13,636	14,375	13,252	12,092	10,825	10,502
Special alpha and dissolving	59	56	71	52	40	26	[b]	[b]	[b]	[b]	[b]
Sulphite, total[c]	2,956	3,011	2,971	3,240	3,276	2,986	3,333	3,229	3,144	2,583	2,519
Bleached[c]	2,063	2,068	1,944	2,037	2,029	1,856	1,856	1,792	1,680	1,346	1,277
Unbleached	893	943	1,027	1,203	1,247	1,161	1,477	1,437	1,465	1,237	1,242
Sulphate, total	10,426	10,278	9,136	9,310	8,381	6,678	6,663	5,860	5,141	4,680	4,588
Bleached	3,148	2,906	2,500	2,383	1,862	1,484	1,305	1,068	833	756	714
Semibleached	363	354	308	330	389	277	251	199	184	168	156
Unbleached	6,915	7,018	6,328	6,597	6,130	4,916	5,107	4,594	4,124	3,756	3,719
Soda	495	504	461	484	559	526	521	520	492	440	418
Groundwood	2,634	2,523	2,610	2,752	2,483	2,184	2,482	2,328	2,133	1,905	1,830
Defibrated, exploded, etc.	1,191	1,143	1,064	944	932	602	742			684	661
Semichemical	1,121	1,022	828	797	685	502	485	1,315	1,181	533	486
Screenings, damaged, etc.	152	144	144	159	153	131	149				

[a] Preliminary. [b] Included in "bleached sulphite" for 1944–48. [c] Includes "special alpha and dissolving" for 1944–48.
Note: Detail may not add to totals because of rounding.
Source: Bureau of the Census, U. S. Department of Commerce.

1954, totaling 6,082,000 tons, was only slightly less than the indicated record consumption of 6,090,000 tons in 1953. Imports of newsprint, largely from Canada, totaled 4,992,000, recording a slight decline under 1953. United States exports of newsprint in 1954 amounted to 140,000 tons, being nearly three times greater than in 1953. Inventories of newsprint paper in the hands of publishers and domestic mills showed only a moderate downward trend from Jan. 1, through Dec. 31, 1954, amounting to a decline in stocks of 38,000 tons.

Wood pulp production in the United States in 1954 was 18.3 million tons compared with 17.5 million tons in 1953; and 16.5 million tons in both 1952 and 1951. Supplementing United States production of wood pulp in 1954 were imports of 2050 thousand tons, bringing total new supply last year to approximately 20.4 million tons. From the standpoint of distribution, exports accounted for 442 thousand tons; United States consumption in paper and board manufacture absorbed 19,034 thousand tons; non-paper users accounted for 762 thousand tons; and the balance into inventories.

United States consumption of total wood pulp in 1954 in paper and board plus nonpaper users, amounting to 19.8 million tons, compares with 19.5 million tons in 1953; 18.0 million tons in 1952; and 18.5 million tons in 1951.

The upward trend in wood pulp consumption as a major raw material in paper and board production, influenced to an important degree by the upsurge in the new advances in hardwood pulping, including semichemical and chemigroundwood, is indirectly disclosed by the lowered level of waste paper consumption in 1954. Last year, total waste paper consumption was 8064 thousand tons as compared with 8531 thousand tons in 1953; 7881 thousand tons in 1952, and 9071 thousand tons in 1951.

From the standpoint of dollar value of manufacturers sales of pulp, paper, and board and products, the industry also set a new high record in 1954. Last year sales totaled $8738 million compared with $8704 million in 1953, $7979 million in 1952 and $8477 million in 1951.

A sizable part of the movement of many grades and products of the industry move to final demand through wholesale paper merchants. In 1954 such products were valued at $2681 million as against $2587 million

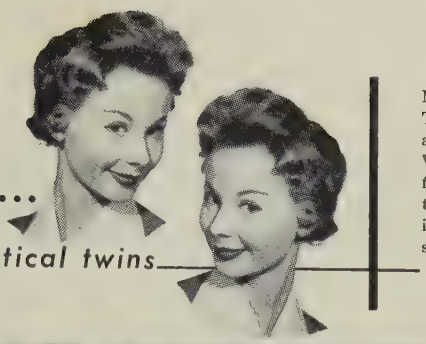
Table XI. Wood Pulp—Year-End Inventories, Pulp, Paper, and Board Mills Only, 1945–54
(1000 short tons)

Item	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945
Wood pulp, total	674	655	711	611	492	512	710	710	490	555
Special alpha and dissolving	63	54	63	24	15	29	[b]	[b]	[b]	[b]
Sulphite, total[c]	215	228	256	239	193	238	370	369	232	299
Bleached[c]	124	115	120	112	86	100	157	163	107	127
Unbleached	91	113	136	127	107	138	213	206	125	173
Sulphate, total	305	288	298	231	197	147	226	244	176	179
Bleached	190	178	166	114	108	69	67	65	36	39
Semibleached	16	15	11	8	5	5	7	7	4	6
Unbleached	99	95	121	110	84	73	152	171	135	135
Soda	16	17	16	16	11	15	24	22	17	12
Groundwood	53	53	63	85	70	65	74	63	56	53
Miscellaneous	22	15	15	17	7	17	16	13	9	12

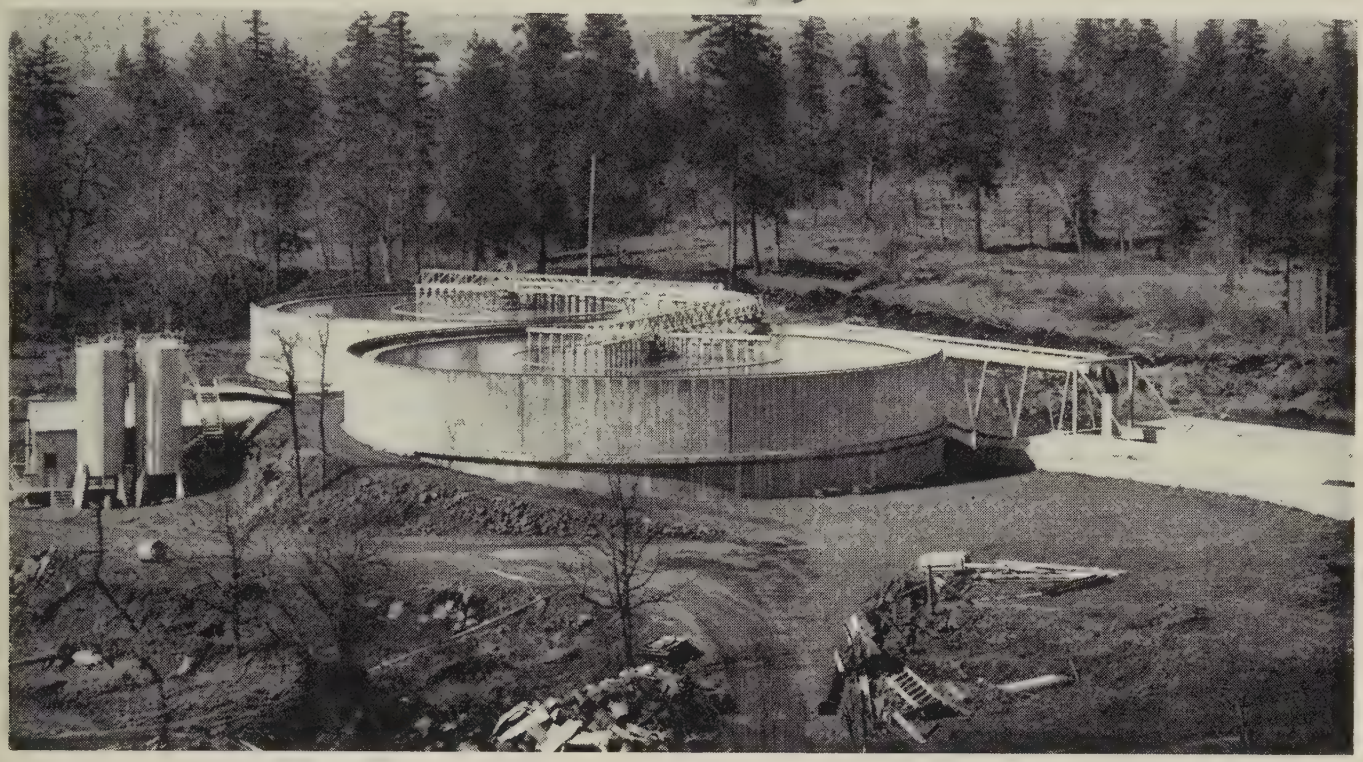
[a] Preliminary. [b] Included in "bleached sulphite" for 1945–48. [c] Includes "special alpha and dissolving" for 1945–48.
Source: Bureau of the Census, U. S. Department of Commerce.

in water treatment problems...

you won't find identical twins



No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.



At St. Helens Pulp & Paper Company

Fluctuating feed characteristics and changing process needs require conventional treatment in combination units

Clear, process water for production of bleach pulp has been a serious problem at the St. Helens Pulp & Paper Company mill at St. Helens, Oregon. Raw water characteristics fluctuate widely because of the tidal action of the Pacific, and the presence of some wastes in the Willamette and Columbia Rivers which join just below the plant. Feed volume fluctuates too — because of changing process needs.

In 1952, water analysis showed 14 to 68 ppm total hardness, 20 to 200 ppm turbidity and 20 to 50 ppm color. The two 120′ dia. Dorrco Clariflocculators shown above were specified to produce 20 MGD of finished water containing no more than 5 ppm color and 5 ppm hardness. Combination units, operating at conventional rates of flow — ideally suited for the changing conditions at St. Helens.

For more information on the complete line of Dorr-Oliver water treatment units, write for Bulletin No. 9141 to Dorr-Oliver Inc., Stamford, Conn.; *in Canada*, 26 St. Clair Avenue East, Toronto 5.

Every day, nearly 8 billion gallons of water are treated in Dorr-Oliver equipment.

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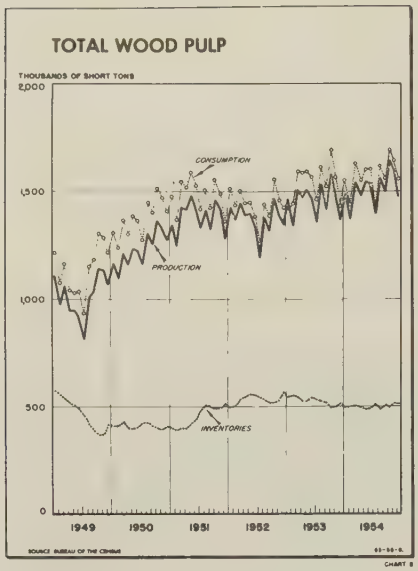
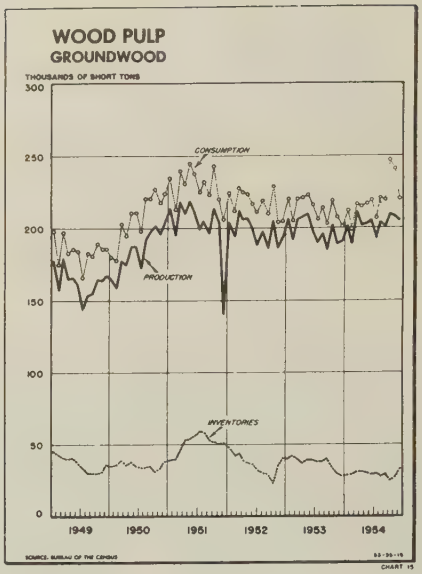
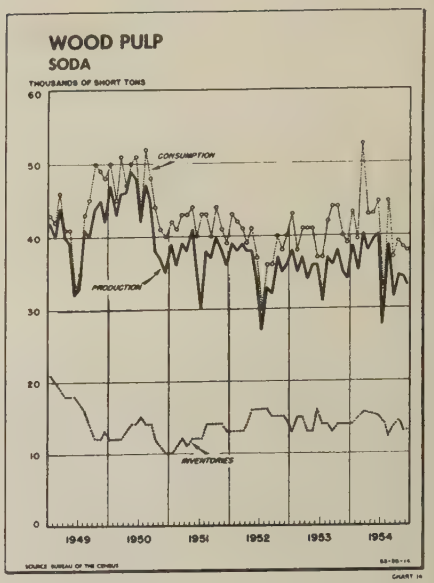
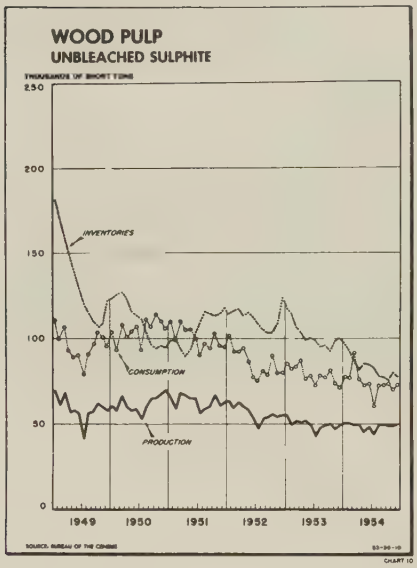
STAMFORD • CONNECTICUT • U.S.A.


TOTAL WOOD PULP
THOUSANDS OF SHORT TONS
2,000
1,500
1,000
500
0
CONSUMPTION
PRODUCTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS


WOOD PULP
GROUNDWOOD
THOUSANDS OF SHORT TONS
300
250
200
150
100
50
0
CONSUMPTION
PRODUCTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS


WOOD PULP
SODA
THOUSANDS OF SHORT TONS
60
50
40
30
20
10
0
CONSUMPTION
PRODUCTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS


WOOD PULP
UNBLEACHED SULPHITE
250
200
150
100
50
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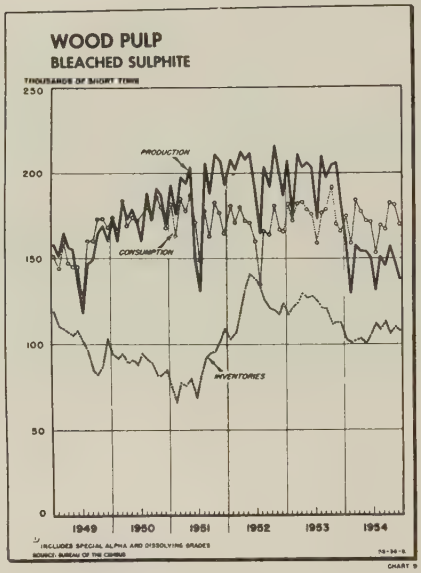
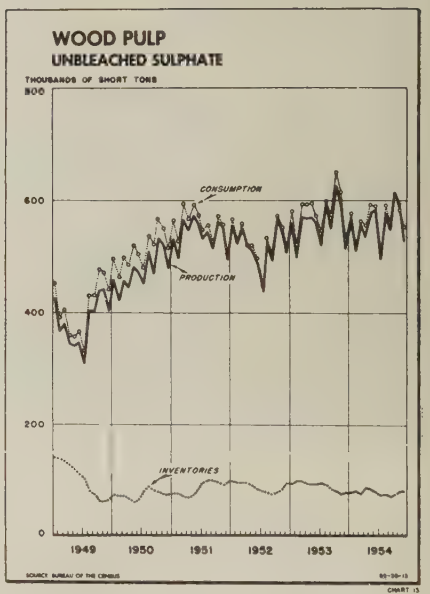
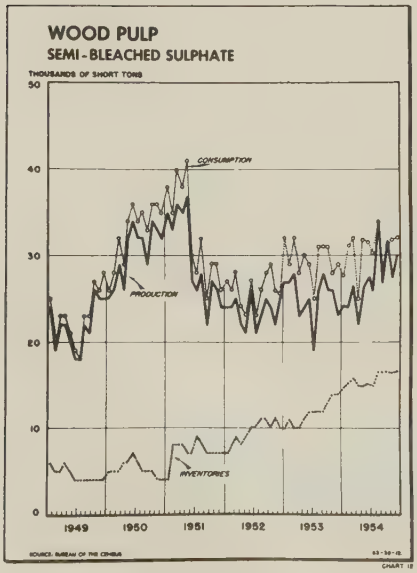
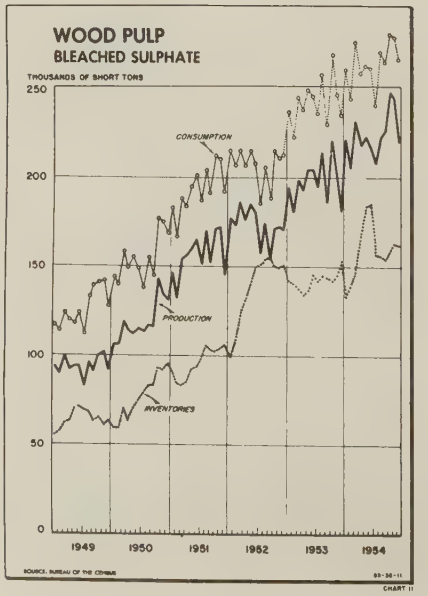
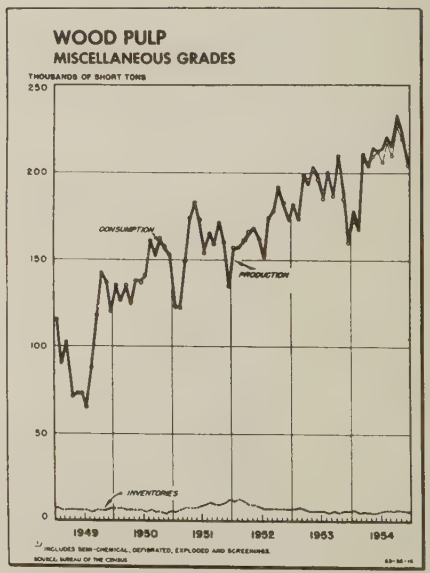
INVENTORIES
CONSUMPTION
PRODUCTION
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS


WOOD PULP
BLEACHED SULPHITE
250
200
150
100
50
0
PRODUCTION
CONSUMPTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS

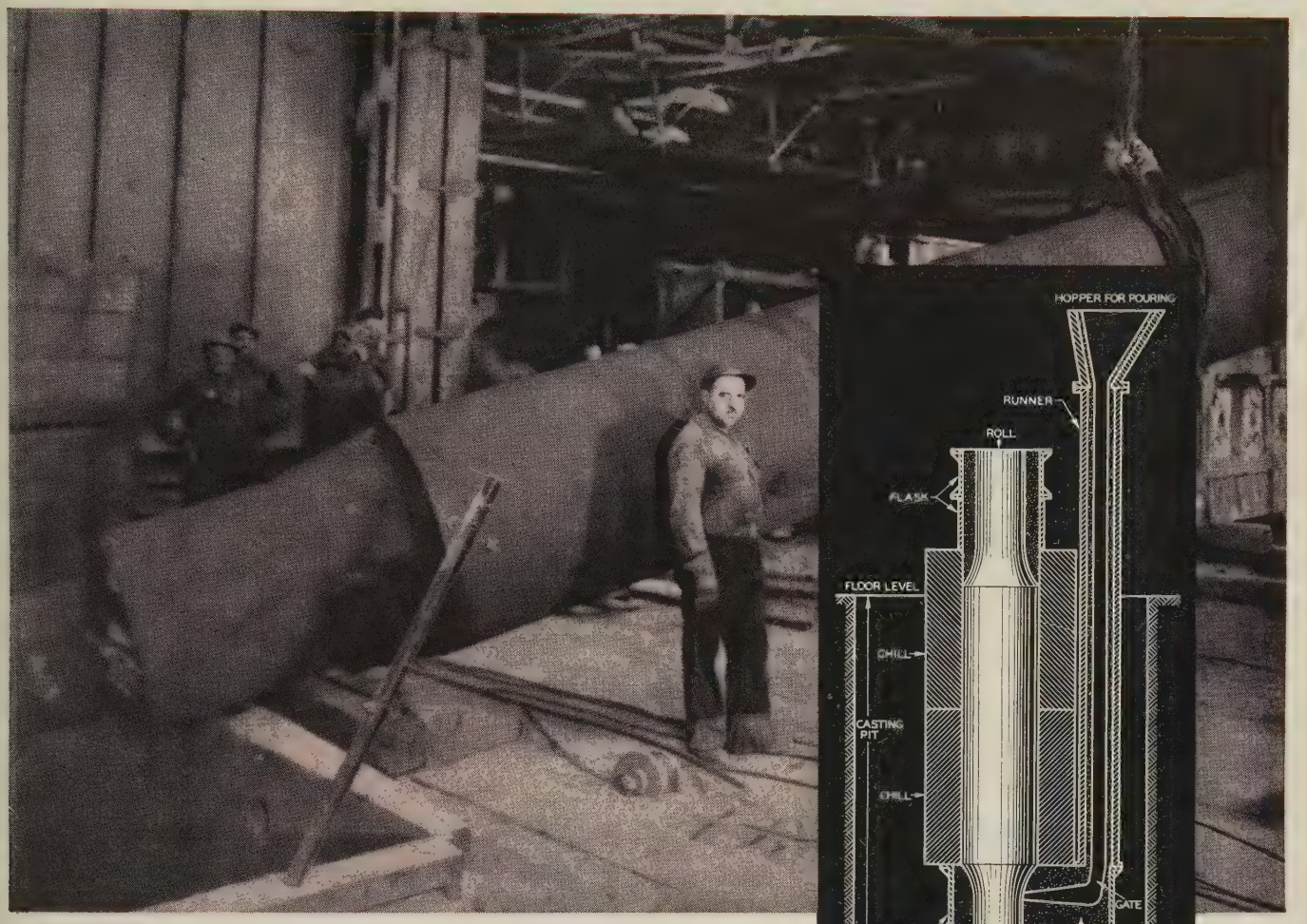

WOOD PULP
UNBLEACHED SULPHATE
THOUSANDS OF SHORT TONS
800
600
400
200
0
CONSUMPTION
PRODUCTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS


WOOD PULP
SEMI-BLEACHED SULPHATE
THOUSANDS OF SHORT TONS
50
40
30
20
10
0
CONSUMPTION
PRODUCTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS


WOOD PULP
BLEACHED SULPHATE
THOUSANDS OF SHORT TONS
250
200
150
100
50
0
CONSUMPTION
PRODUCTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS


WOOD PULP
MISCELLANEOUS GRADES
THOUSANDS OF SHORT TONS
250
200
150
100
50
0
CONSUMPTION
PRODUCTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS

CLOSE CHILL CONTROL



why Farrel rolls last longer— cost less to maintain

The photograph above shows a 75-ton casting for a large calender roll being removed from a 35-foot deep casting pit in the Farrel foundry. Within a vertical pit such as this, are the molds in which the roll is cast.

The body or barrel of a roll is made in an iron mold or chiller. Sand molds are used for the necks. Sand is a poor conductor of heat, so when molten iron is poured into a mold of this material, cooling is comparatively slow. This results in an easily workable casting, suitable for roll necks. Where the molten metal comes into contact with the iron chiller, cooling is rapid, because iron is a good conductor of heat. This causes the surface of the roll body to harden, or "chill." The body of the roll beneath the chilled surface cools slowly, forming a gray iron structure. The chilled surface of the roll varies in depth from 3/8" in small, to 2" in large diameter rolls.

This white iron skin or chill provides an extremely hard surface which can be given a mirror finish. Proper SURFACE HARDNESS prolongs accuracy of the roll face, lengthens the time between regrindings, and as a result cuts roll maintenance costs. CORRECT DEPTH OF CHILL means that the roll may be reground many times before its usefullness is ended.

To produce high quality chilled rolls from 5" to 72" in diameter and up to 312" in face length requires specialized experience and facilities —the kind that Farrel has developed in a century of making rolls.

Ask for bulletin No. 116 which will tell you more about these long-lived rolls.

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Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Chicago, Los Angeles, Houston

Farrel-Birmingham®

FB-932

Table XII. Wood Pulp in Other than Paper and Board Manufacture, 1951–54

(1000 short tons)

	1954[a]	1953	1952	1951
Receipts, total	763	778	783	730
Special alpha and dissolving	663	690	705	n.a.
All other	100	88	78	n.a.
Domestic, total	519	544	560	488
Special alpha and dissolving	451	485	502	n.a.
All other	68	59	58	n.a.
Imports from Canada,[b] total	244	227	223	242
Special alpha and dissolving	212	202	203	n.a.
All other	31	25	20	n.a.
Consumption, total	762	799	755	714
Special alpha and dissolving	661	713	676	n.a.
All other	101	86	79	n.a.
Inventories, year-end, total	85	83	106	78
Special alpha and dissolving	78	77	101	72
All other	7	6	5	6

[a] Preliminary. [b] Includes a small quantity from overseas.
n.a. Not available.
Source: Bureau of the Census, Department of Commerce.

in 1953; $2461 million in 1952, and $2678 million in 1951.

Comparing 1954 value of sales data as related to volume of production against corresponding data for 1953 indicates that the price levels of the industry remained generally steady during the past year. This is borne out by the price indexes compiled by the Bureau of Labor Statistics which show only minor or no changes between the 1954 and 1953 price levels of wood pulp, the major grades of paper and paperboard, or in converted products. Waste paper prices (except for books and magazines) showed moderate declines in 1954 from their 1953 levels. The average price index of all commodities (except foods) averaged 114.5 in 1954 (1947–49 equalled 100) as against 114.0 in 1953. Pulp, paper, and products as a group stood at 116.3 for 1954 as against 116.1 in 1953.

In the field of foreign trade, the industry continues to be a major factor. In 1954, imports (consisting largely of pulpwood, wood pulp, and newsprint) totaled $925 million, while exports of pulp, paper, board, and products amounted to $228 million.

Production Workers and Wages, Pulp, Paper, and Allied Products Industries

Year	Average number of wage earners, thousands	Total dollar wages, millions	Year	Average number of wage earners, thousands	Total dollar wages, millions
1899	94	36	1950	404	1284
1909	145	68	1951	420	1436
1919	208	213	1952	422	1514
1929	233	287	1953	441	1676
1939	265	310	1954[a]	436	1680
1949	382	1111			

[a] Preliminary.
Source: Prepared by the Forest Products Division, Business and Defense Services Administration, based on data furnished by the Bureau of Labor Statistics, Department of Labor.

From the standpoint of employment, the pulp, paper, board, and products manufacturing industries rank very important. In 1954, the average number of wage earners totaled 436,000 and were paid wages amounting to $1680 million.

Table XIII. Market Wood Pulp—Paper and Paperboard Mills Only—Annual Receipts, Consumption, and Inventories, 1947–54

(1000 short tons)

Item	1954	1953	1952	1951	1950	1949	1948	1947
Wood pulp, total all grades:								
Receipts, total	2447	2490	2276	2819	2916	2152	2571	2709
Domestic	1226	1155	1120	1297	1213	938	1060	1189
Imported	1221	1335	1156	1522	1703	1214	1511	1520
Canada and Newfoundland	840	819	846	1054	976	707	917	784
European	381	516	310	468	727	507	594	736
Consumption (purchased pulp) total	2422	2500	2252	2742	2902	2325	2586	2511
Inventories (purchased pulp) total	395	380	404	395	332	342	519	532
Domestic shipments, total[b]	1145	1087	1059	1254	1147	905	1024	1041
Sulphite, all grades:								
Receipts, total	1035	1107	1139	1398	1466	1209	1474	1554
Domestic	534	563	595	702	672	588	649	722
Imported	501	544	544	696	794	621	825	832
Canada and Newfoundland	365	336	402	498	480	370	525	492
European	136	208	142	198	314	251	300	340
Consumption, total	1039	1147	1112	1362	1484	1313	1455	1432
Inventories, total	169	179	213	202	163	194	297	283
Domestic shipments[b]	479	489	563	720	655	576	642	655
Sulphate, all grades:								
Receipts, total	1065	1029	775	947	1003	614	714	780
Domestic	508	445	351	398	325	187	200	260
Imported	557	584	424	549	678	427	514	520
Canada and Newfoundland	353	333	281	318	301	208	236	154
European	204	251	143	231	377	219	278	366
Consumption, total	1046	1003	769	919	973	666	720	730
Inventories, total	180	164	140	141	120	102	158	188
Domestic shipments[b]	535	438	339	362	291	181	199	200
Groundwood and other grades:								
Receipts, total	347	354	361	474	445	329	383	375
Domestic	184	147	173	197	216	163	211	207
Imported	163	207	188	277	229	166	172	168
Canada and Newfoundland	122	150	163	238	187	129	156	138
European	41	57	25	39	42	37	16	30
Consumption, total	337	350	373	461	442	346	411	349
Inventories, total	46	37	51	52	49	46	64	61
Domestic shipments[b]	131	160	156	172	201	148	183	186

[a] Market pulp consists of domestic or imported pulp purchased from a mill not under the same ownership control as the purchaser.
[b] Shipments by domestic pulp mills to domestic paper and paperboard mills. The difference between shipments and receipts may be explained in part by "in transit" pulp and probable incomplete reports on domestic shipments.

You get more than quality glue when you specify Armour!

In every phase of its manufacture, Armour glue is under the constant supervision of one of the most comprehensive quality control systems in the adhesive industry. This system guarantees the unvarying high quality of every order of Armour glue. But selling and delivering glue is, to us, only the first step of a transaction. We know that our clients have individual applications and, perhaps, problems, and we expect to assist in every way possible.

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Name.....*Title*.....

Firm.....

Address.....

City.....*Zone*.....*State*.....

T5

Table XIV. Waste Fibrous Materials—United States Annual Receipts, Consumption, and Inventories, 1944–54

(1000 short tons)

Item	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944[b]
Receipts, total	9,200	9,769	9,045	10,715	9,399	7,759	9,120	9,434	8,895	8,194	8,359
Waste paper	8,025	8,427	7,815	9,252	7,964	6,522	7,605	7,875	7,487	6,824	6,937
Rags	308	320	318	396	440	378	407	445	427	392	431
Other	867	1,022	912	1,067	995	859	1,108	1,114	981	978	991
Consumption, total	9,276	9,785	9,092	10,528	9,395	7,815	9,036	9,535	8,661	8,143	8,244
Waste paper	8,064	8,531	7,881	9,071	7,956	6,600	7,584	8,009	7,278	6,800	6,859
Rags	317	325	325	389	442	382	416	462	403	414	428
Other	895	929	886	1,068	997	833	1,036	1,064	980	929	957
Inventories, total	1,023	1,082	1,095	1,163	966	998	1,129	1,087	1,078	840	837
Waste paper	452	479	522	589	387	397	517	521	515	327	315
Rags	40	49	54	61	54	56	58	67	77	53	79
Other	531	554	519	513	525	545	554	499	486	460	443

[a] Preliminary. [b] 1944 receipts and inventories were reported by a few mills other than paper and paperboard mills. Data for the remaining years are for paper and paperboard mills only.

Source: Bureau of the Census, U. S. Department of Commerce, and Forest Products Bureau, War Production Board.

Table XV. Paper and Paperboard—United States Production, 1944–54

(1000 short tons)

Type of product	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944
All types	26,657	26,528	24,423	26,048	24,375	20,316	21,897	21,114	19,278	17,371	17,183
Paper, total	12,971	12,722	12,197	13,011	12,064	10,349	11,119	10,705	9,788	8,457	8,220
Newsprint	1,192	1,069	1,109	1,108	1,013	918	876	833	773	725	721
Groundwood	808	771	806	791	705	674	772	821	776	636	593
Printing	611	600	589	519	488	484	538	546	474	351	314
Converting and other	197	171	217	172	217	190	234	275	302	285	279
Machine coated paper	1,215	1,182	1,096	1,113	1,020	887	809	627	486	334	305
Book paper	1,560	1,623	1,482	1,610	1,579	1,416	1,570	1,581	1,447	1,167	1,131
General printing	856	1,020	959	1,035	1,008	926	1,067	1,070	972	777	729
Converting	582	593	513	558	557	476	485	498	457	380	400
Other book paper	22	10	10	18	14	14	18	13	18	10	2
Fine paper	1,324	1,298	1,295	1,366	1,199	1,015	1,141	1,172	1,160	1,001	974
Writing paper	1,043	1,034	1,052	1,093	958	806	909	918	902	811	777
Rag	115	123	132	161	138	120	138	174	176	191	118
Chemical wood	928	911	920	932	820	686	771	744	726	620	659
Cover and text	81	70	59	63	61	63	72	93	93	59	52
Bristols	107	107	106	109	102	79	88	87	97	67	84
Thin paper[b]	93	87	78	101	78	67	72	73	68	63	61
Coarse paper, total	3,429	3,399	3,238	3,267	3,298	2,758	3,027	2,903	2,690	2,403	2,314
Glassine, greaseproof and vegetable parchment	138	149	138	177	162	141	151	156	158	140	139
Wrapping	630	640	651	705	713	692	726	667	763	715	650
Bag paper	936	946	797	838	754	690	736	540	524	365	375
Shipping sack	782	710	753	849	748	510	567	671	550	423	392
Converting	943	954	899	1,057	921	725	847	869	695	760	758
Special industrial paper including absorbent paper	526	554	514	536	460	334	415	389	375	327	335
Sanitary paper	1,320	1,278	1,148	1,244	1,148	1,008	983	894	861	824	808
Tissue paper	241	232	209	229	217	187	205	195	184	157	158
Building paper and insulation	1,356	1,316	1,298	1,386	1,425	1,151	1,321	1,289	1,036	883	881
Board, all types, total	13,686	13,806	12,226	13,037	12,311	9,967	10,778	10,409	9,490	8,914	8,963
Container board	6,432	6,613	5,766	6,323	5,830	4,680	5,079	4,944	4,315	4,131	4,228
Folding boxboard	2,485	2,429	2,193	2,362	2,352	1,943	2,024	2,257	2,317	2,092	2,116[c]
Special food board	941	968	799	772	655	516	443	460	434	374	387
Set-up boxboard	710	763	687	733	712	617	596	595	521	721	750
Cardboard	79	75	69	85	87	83	87	92	89	71	70
Building board	1,507	1,379	1,305	1,269	1,220	839	1,270	1,072	956	895	1,087[d]
Wet machine board	132	152	139	148	166	131	142	150	138	112	130
Other board	1,400	1,427	1,268	1,345	1,289	1,158	1,137	839	720	518	195

[a] Preliminary. [b] Includes small amounts of "other fine papers." [c] Includes all grades of bending board. [d] Includes liner for gypsum and stock for laminated wallboard.

Source: Prepared by the Forest Products Division—Business and Defense Services Administration, based upon data from Bureau of the Census, U. S. Department of Commerce.

Table XVI. Newsprint—United States Production, Imports, Exports, Domestic Consumption and Inventories

(1000 short tons)

Item	1954[a]	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944
Production	1192	1069	1109	1108	1013	918	876	833	773	725	721
Imports	4992	5004	5033	4963	4863	4639	4395	3958	3492	2669	2491
Re-exports	n.a.	n.a.	n.a.	n.a.	n.a.	5	2	2	2	3	9
Exports	140	47	105	71	44	39	28	28	28	44	31
Total supply	6044	6026	6034	6000	5832	5513	5241	4761	4235	3347	3172
Inventories, total	522	560	624	530	433	457	467	386	308	273	350
Publishers[b]	516	552	612	522	425	446	458	377	293	266	342
Mill	6	8	12	8	8	11	9	9	15	6	7
Change in stocks	−38	−64	+94	+97	−24	−10	+81	+78	+35	−77	−28
Apparent consumption	6082	6090	5940	5903	5856	5523	5160	4683	4200	3424	3200

[a] Preliminary. [b] Reported by 422 publishers of 525 newspapers consuming approximately 76% in 1952–54; 75.5% in 1951; 76.5% in 1950; 77% in 1949; 78% in 1948; and 75% in 1947; 73% in 1946; 70% in the first half and 71% in second half of 1945; 72.5% in 1944; and 75% in 1943. n.a. Not available.

Source: Production, import, and export figures, Bureau of the Census, U. S. Department of Commerce; Publishers inventories, American Newspaper Publishers Association; mill inventories, News Print Service Bureau; consumption equals supply adjusted for change in stocks.

BECCO Processes

Ask for facts on BECCO's 2-stage hypochlorite-peroxide bleaching of sulfites and semichemicals

The 2-stage hypochlorite-peroxide process produces a high yield of pulp of fine quality with exceptional brightness and stability. Investment for equipment is low and chemical cost is moderate.

You can bleach many sulfite pulps to brightness levels of 85; some neutral sulfite semichemical pulps to 80. The process also has important values for the bleaching of agricultural residue pulps.

A moderate or high-density peroxide stage gives you high bleaching efficiency in terms of brightness gain per chemical dollar.

Ask to see Becco technical consultants or write for Bulletin D-14 giving complete description and schematics of process and equipment, tabulated bleaching data on many pulp types, and comparisons on both moderate and high-density bleaching by the Becco 2-stage hypochlorite-peroxide bleaching process.

Other Becco paper industry processes are described in the following bulletins: D-1 Becco Methods for Soda Pulp Bleaching, D-2 Becco Peroxide Bleaching Methods for Sulfite Pulps, D-3 Becco Procedures for Bleaching Kraft Pulps, D-4 Data on Flax Pulp Bleaching, D-5 Becco Peroxide Bleaching Methods for Semichemical Pulps, D-7 Becco Pulp Bleaching with Mixed Peroxides, D-8 Becco Pulp Dryer Steep Bleaching, D-10 Pretreatments for Groundwood Pulps, D-11 Becco Peracetic Acid 40% applications in Pulp and Paper Mills, D-12 Starch Solubilization with Becco Potassium Persulfate, D-13 Bleaching of Groundwood Pulp with Hydrogen Peroxide. Write for complete bulletin list and any of the above you desire.

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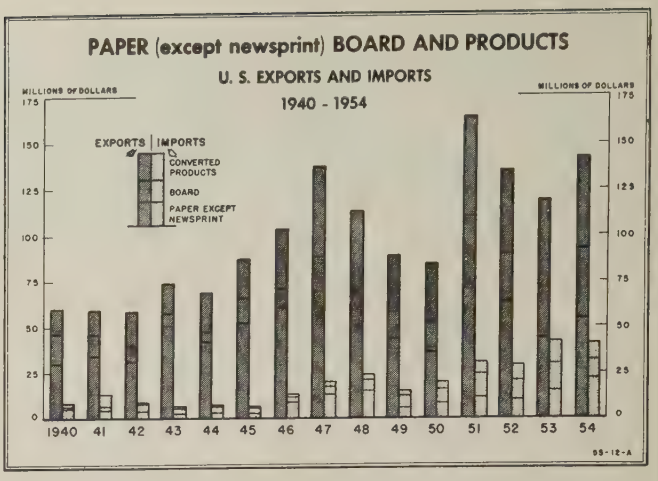
INDUSTRY TRENDS

Pulpwood

The 1954 pulpwood picture was one of satisfactory supplies, a record consumption of 29.2 million cords, a further reduction of inventories from the high levels of 1951 and 1952, and a continued increase in the use of hardwoods and sawmill waste.

The record level of receipts reached in 1954 at 28.6 million cords was 2.5% above the 1953 level. Domestic receipts of nearly 27.0 million cords was 2.5% over 1953, while imports of 1.6 million cords pulpwood in 1954 increased 5.0% from the 1953 level.

Domestic consumption of pulpwood in 1954 at 29.2 million cords was 3.8% above 1953 while inventories of pulpwood dropped 10.3%. Regionally, there was considerable variation from the United States total pulpwood pattern. In the Northeast region 1954 consumption was virtually the same as in 1953, while inventories declined over 300,000 cords down to 1,335,000 cords, the lowest year-end inventory, with the exception of 1950, since 1946. The receipts and consumption of pulpwood in the Appalachian region were above the 1953 level while inventories showed a decline. The increase of 155,000 cords in consumption was due in large degree to the new newsprint mill which began operation in Tennessee during the year. The consumption of pulpwood in the Lake States region during 1954 was 2,957,000 cords about 80,000 cords below the 1953 rate. The consumption of 15,014,000 cords of pulpwood in the Southern region, (over half of the total United States consumption) was 262,000 cords above the previous record set in 1953. The Western region consumption of pulpwood in 1954 at 5,425,000 cords showed the largest increase (741,000 cords) over the previous year. It should be noted that this increase does not represent that amount of virgin timber since a large percentage of the pulpwood consumed in the West consists of chips produced from sawmill and other wood waste.


PAPER (except newsprint) BOARD AND PRODUCTS
U. S. EXPORTS AND IMPORTS
1940 - 1954
MILLIONS OF DOLLARS
EXPORTS | IMPORTS
CONVERTED PRODUCTS
BOARD
PAPER EXCEPT NEWSPRINT
1940 41 42 43 44 45 46 47 48 49 50 51 52 53 54

Wood Pulp

Wood pulp production in 1954 again set a record reaching 18,341,000 tons, an increase of 4.6% over 1953. All grades of pulp except unbleached sulphite showed production increases over a year ago, with bleached sulphate showing the largest (295,000 tons) and dissolving and special alpha next with a gain of 114,000 tons, due largely to several new mills that came into production during 1954. Semichemical pulp production continued to grow in importance reaching 1,126,000 tons in 1954. This represents not only an increase of 100,000 tons over 1953 production, but what is more significant the rise of 620,000 tons since 1949.

Wood pulp consumption in paper and board production also set new records in 1954, reaching 19,034,000 tons, an increase of 1.9% above 1953. Nonpaper uses of wood pulp declined 4.6% to 762,000 tons in 1954. 1954 market wood pulp consumption by paper and

Table XVII. Production of Newsprint in North America

(1000 short tons)

Year	*Total*[a]	*United States*	*Canada*	*Newfoundland*	*Year*	*Total*[a]	*United States*	*Canada*	*Newfoundland*
1954[b]	7176	1192	5984	[c]	1946	5279	773	4143	363
1953	6790	1069	5721		1945	4317	725	3259	333
1952	6796	1109	5687	[c]	1944	3985	721	2992	273
1951	6624	1108	5516	[c]	1943	4030	811	2983	236
1950	6292	1013	5279	[c]	1942	4422	967	3177	277
1949	6092	918	4732	444	1941	4815	1044	3426	345
1948	5859	876	4601	382	1940	4826	1056	3419	351
1947	5653	833	4447	373	1939	4129	954	2869	305

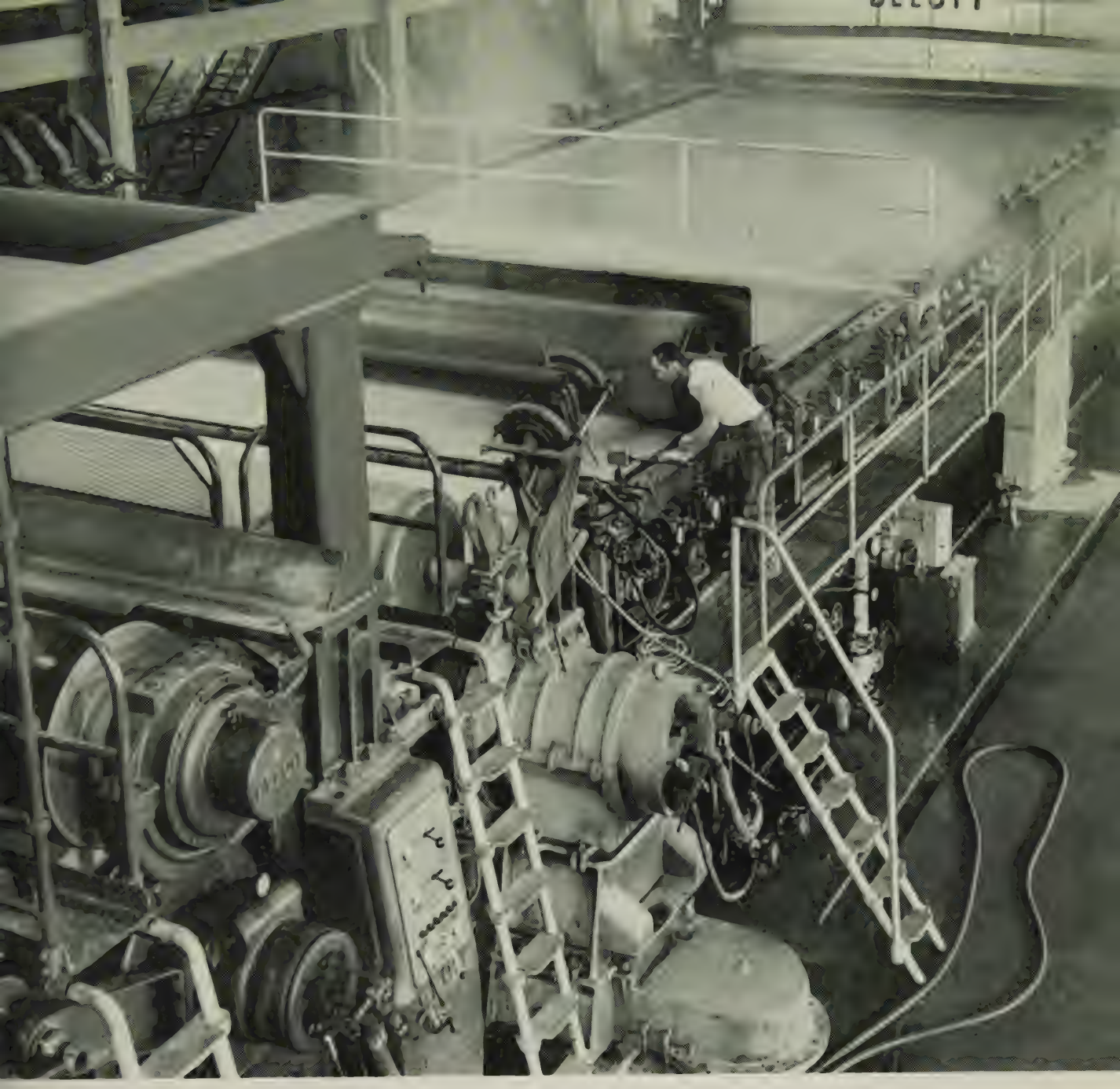
[a] Details may not add to total because of rounding. [b] Preliminary. [c] Data for Canada include figures for Newfoundland.
Source: United States, Bureau of the Census, U. S. Department of Commerce; Canada and Newfoundland, Newsprint Association of Canada.

Table XVIII. Newsprint—United States Imports by Country of Origin

(1000 short tons)

Source	*1954*[a]	*1953*	*1952*	*1951*	*1950*	*1949*	*1948*	*1947*	*1946*
Total[b]	4992	5004	5033	4963	4863	4639	4395	3958	3492
Canada[c]	4864	4841	4850	4756	4690	4382	4127	3829	3478
Finland	122	145	162	160	144	151	132	84	12
Sweden	6	16	16	30	18	37	70	25	1
United Kingdom	[d]	..	..	..	[d]	35	3	..	..
Norway	[d]	3	4	9	4	30	28	6	..
France	..	..	..	5	2	2	28	10	..
All other countries	..	..	1	3	2	1	7	4	..

[a] Preliminary. [b] Data does not necessarily add to total because of rounding. [c] Includes Newfoundland. [d] Less than 500 short tons.
Source: Bureau of the Census, U. S. Department of Commerce.

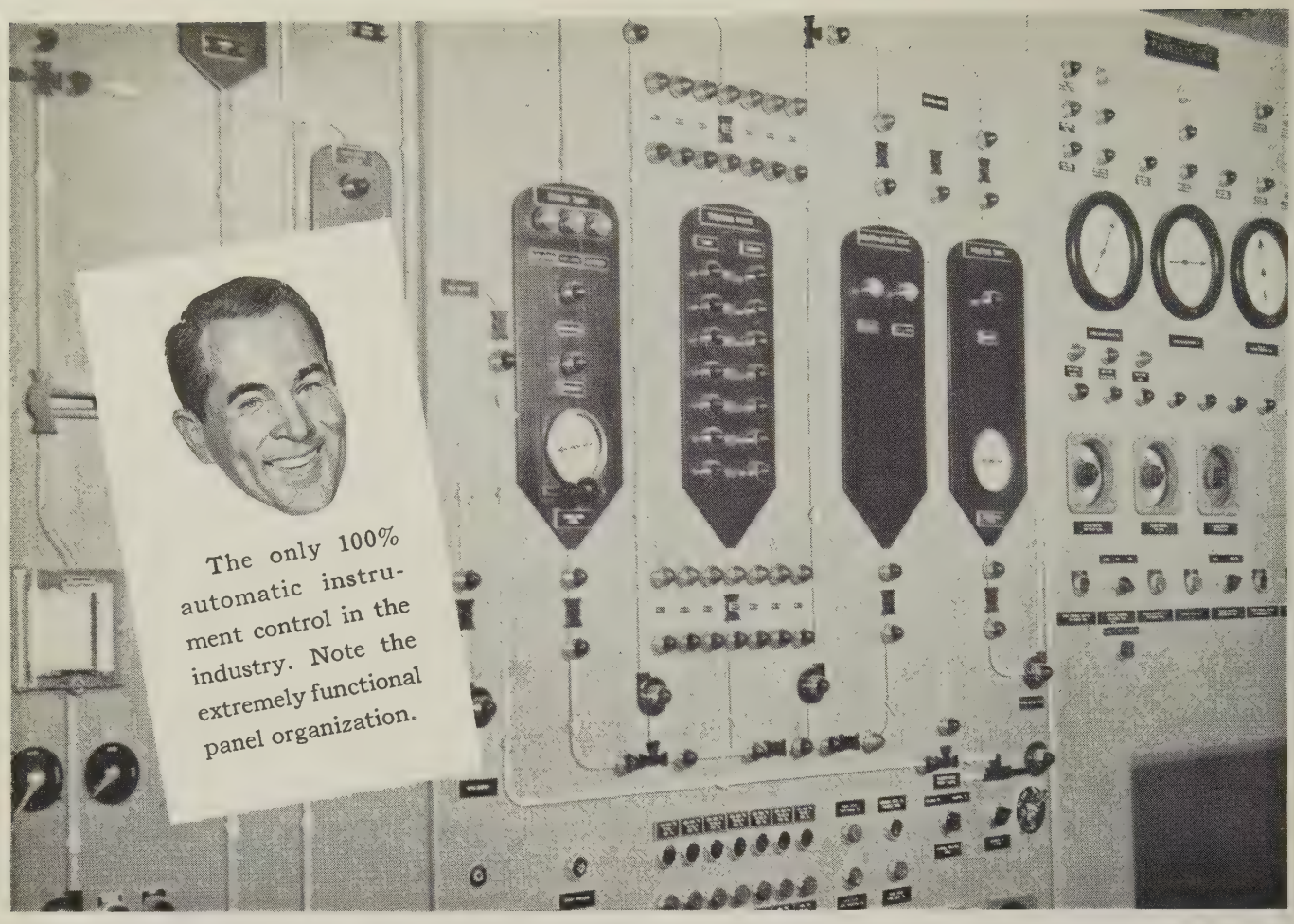


FAST AND FLEXIBLE Rome Kraft Company's big, new Beloit 252" Fourdrinier board machine, at Rome, Georgia, is designed for speeds from 500 to 2000 feet per minute. Pictured are the patented air-cushioned inlet and removable Fourdrinier.

BELOIT

WHEN YOU BUY BELOIT...YOU BUY MORE THAN A MACHINE!

PAPER MACHINERY



HERCULES CORN STARCH: For Assured Uniformity in Quality Paper-Making

brand

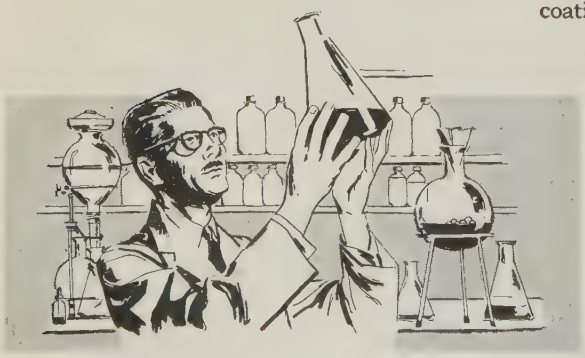
The production of Hercules Brand Corn Starch is under 100% automatic instrument control. This newly perfected process is the only one of its kind. It delivers a starch that meets your specifications exactly!

As a result of fully automatic, completely instrument-controlled production, one batch of a given type of Hercules is just exactly like every other batch of the same type. So you can see that we mean business when we say: Hercules gives you uniformity of quality you can count on. This pays off for you in two important ways:

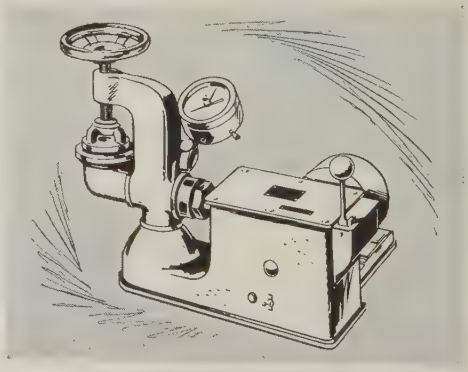
1. You need make fewer spot tests to check uniformity.

2. You receive fewer rejects of your product from your clients.

RESEARCH: All Hercules starches have resulted from extensive *research* in the lab and in the field.



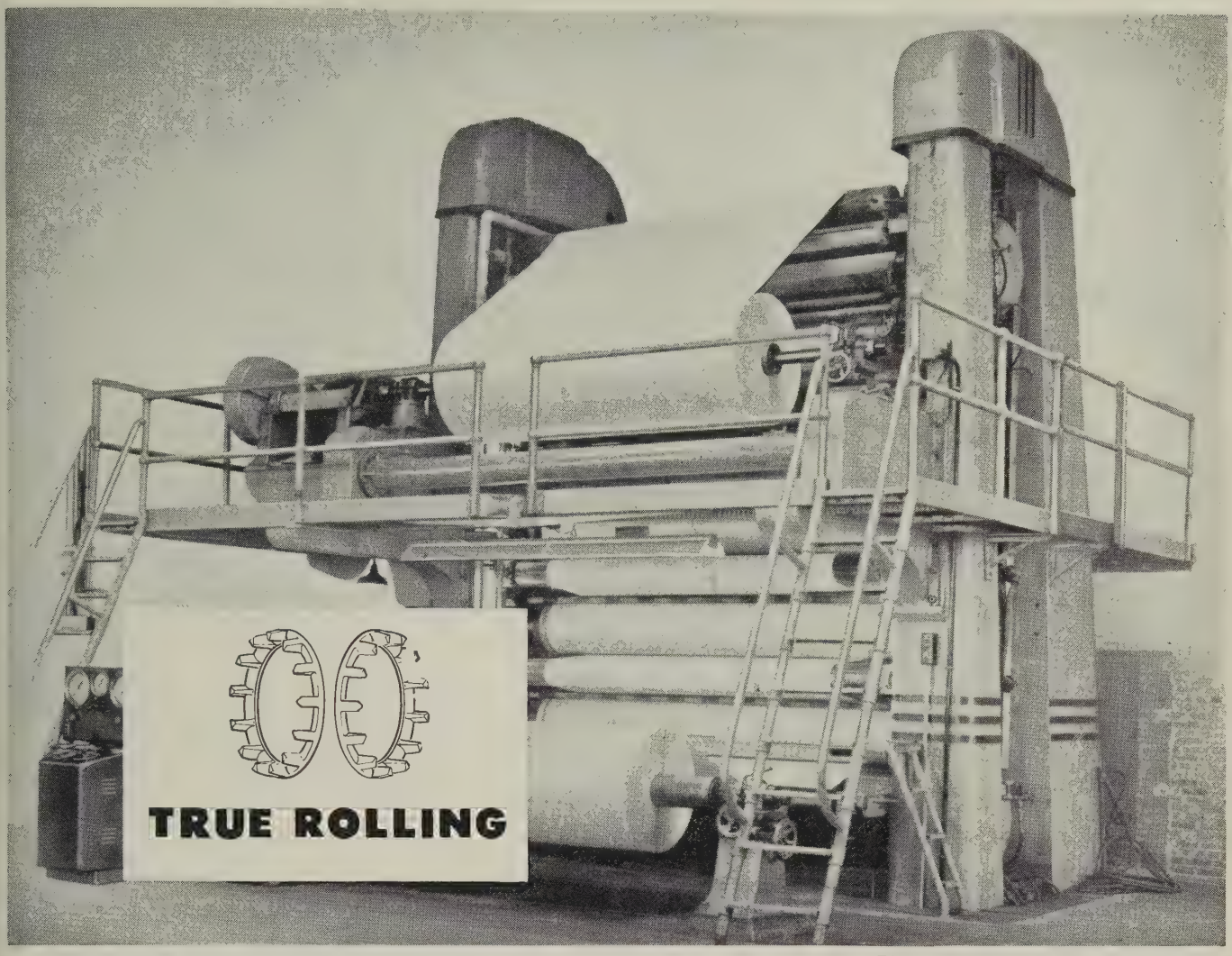
HIGH MULLEN FACTORS are obtained by the use of Hercules starches as beater additives, in "off the machine" coating, and in Calender sizing.



SPEEDY, RELIABLE SERVICE:
You get the Hercules Starch you want when you want it. You're sure of supply. For free technical assistance write to

CORN PRODUCTS REFINING COMPANY
17 BATTERY PLACE • NEW YORK 4, NEW YORK

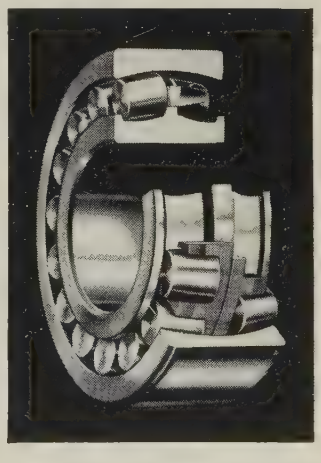
IN THE PAPER INDUSTRY, TORRINGTON *Bearings are used in presses, driers, calenders, wet ends and winders.*



Photograph courtesy of Appleton Machine Co.

TORRINGTON Spherical Roller Bearings

are designed with machined, cast-bronze, land-riding cages—one for each path of rollers—to assure true rolling operation



Other TORRINGTON SPHERICAL ROLLER BEARING features are equally important in assuring top performance. Contact surfaces are precision ground for even load distribution, long bearing life. Rollers and races are carefully heat treated to give maximum resistance to shock and wear.

An integral center flange gives positive radial stability and accurate positioning of thrust loads—an essential factor for longer service life. Contact surfaces possess geometrical conformity, giving ultimate load carrying capacity.

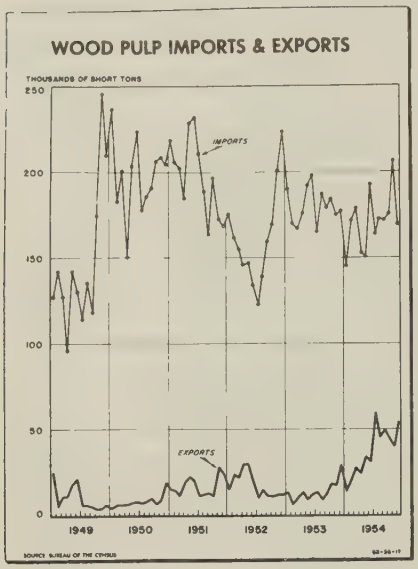
These are reasons why TORRINGTON SPHERICAL ROLLER BEARINGS give you long, low-maintenance service in the toughest, heavy-duty applications. Get the most for your bearing dollar—specify TORRINGTON.

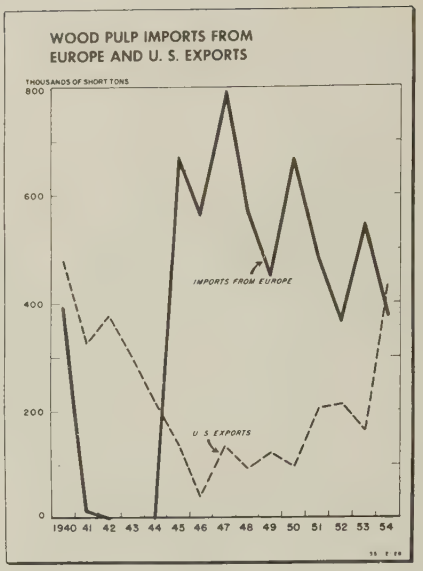
THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.

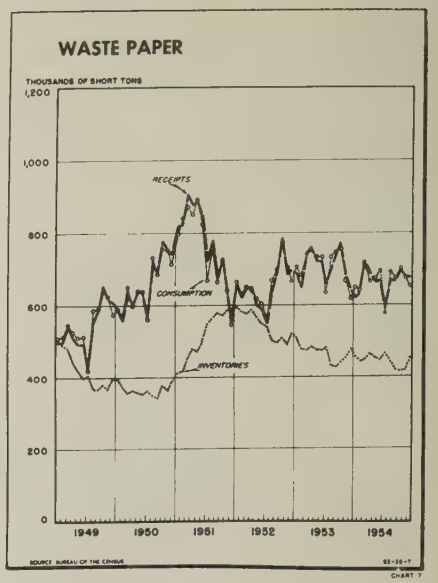
District Offices and Distributors in Principal Cities of United States and Canada

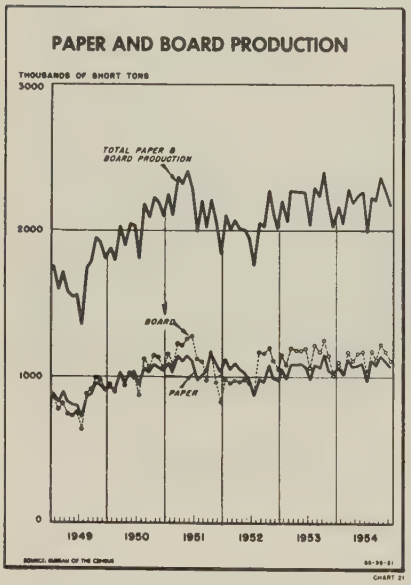
TORRINGTON SPHERICAL ROLLER BEARINGS

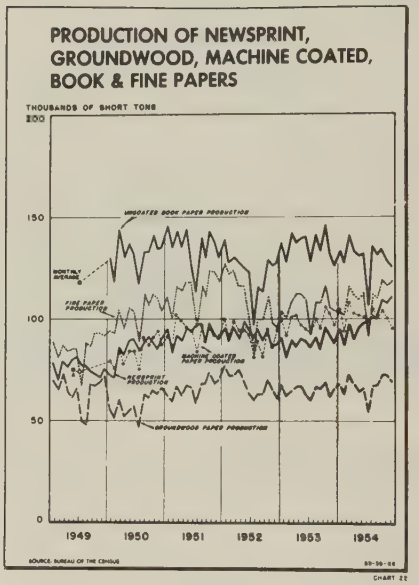
Spherical Roller • Tapered Roller • Cylindrical Roller • Needle • Ball • Needle Rollers

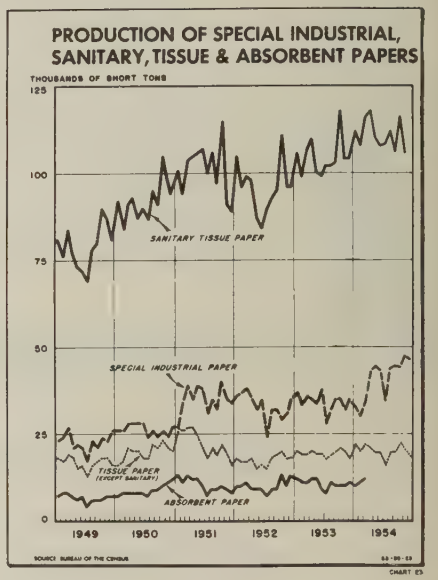

WOOD PULP IMPORTS & EXPORTS
THOUSANDS OF SHORT TONS
250
200
150
100
50
0
IMPORTS
EXPORTS
1949
1950
1951
1952
1953
1954
SOURCE BUREAU OF THE CENSUS

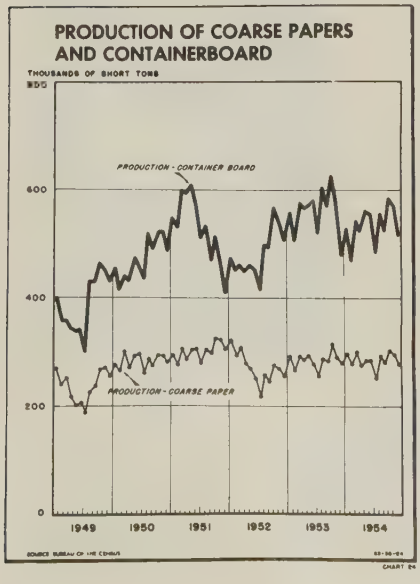

WOOD PULP IMPORTS FROM EUROPE AND U. S. EXPORTS
THOUSANDS OF SHORT TONS
800
600
400
200
0
IMPORTS FROM EUROPE
U. S. EXPORTS
1940 41 42 43 44 45 46 47 48 49 50 51 52 53 54

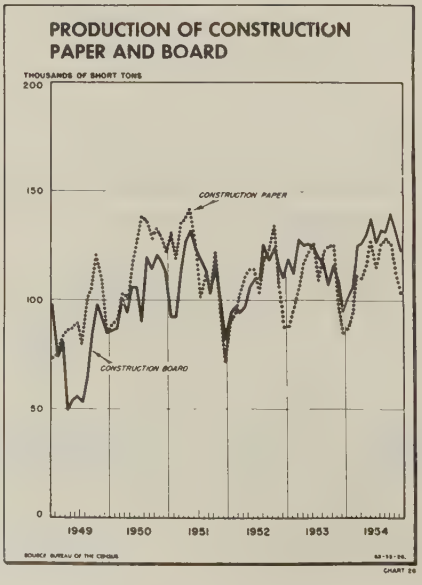

WASTE PAPER
THOUSANDS OF SHORT TONS
1,200
1,000
800
600
400
200
0
RECEIPTS
CONSUMPTION
INVENTORIES
1949
1950
1951
1952
1953
1954
SOURCE BUREAU OF THE CENSUS
CHART 7

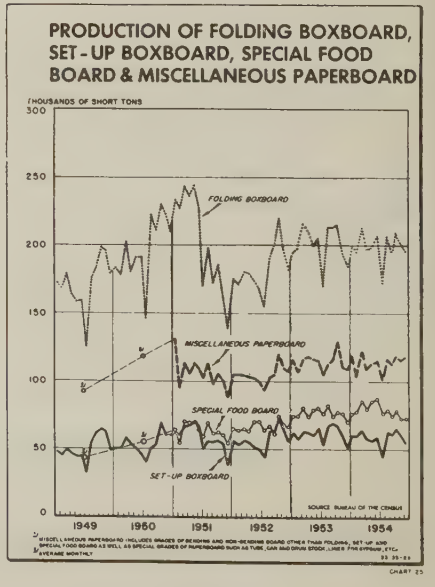

PAPER AND BOARD PRODUCTION
THOUSANDS OF SHORT TONS
3000
2000
1000
0
TOTAL PAPER & BOARD PRODUCTION
BOARD
PAPER
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS
CHART 21


PRODUCTION OF NEWSPRINT, GROUNDWOOD, MACHINE COATED, BOOK & FINE PAPERS
THOUSANDS OF SHORT TONS
200
150
100
50
0
MONTHLY AVERAGE
UNCOATED BOOK PAPER PRODUCTION
FINE PAPER PRODUCTION
MACHINE COATED PAPER PRODUCTION
NEWSPRINT PRODUCTION
GROUNDWOOD PAPER PRODUCTION
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS
CHART 22


PRODUCTION OF SPECIAL INDUSTRIAL, SANITARY, TISSUE & ABSORBENT PAPERS
THOUSANDS OF SHORT TONS
125
100
75
50
25
0
SANITARY TISSUE PAPER
SPECIAL INDUSTRIAL PAPER
TISSUE PAPER (EXCEPT SANITARY)
ABSORBENT PAPER
1949
1950
1951
1952
1953
1954
SOURCE BUREAU OF THE CENSUS
CHART 23


PRODUCTION OF COARSE PAPERS AND CONTAINERBOARD
THOUSANDS OF SHORT TONS
800
600
400
200
0
PRODUCTION - CONTAINER BOARD
PRODUCTION - COARSE PAPER
1949
1950
1951
1952
1953
1954
SOURCE: BUREAU OF THE CENSUS
CHART 24


PRODUCTION OF CONSTRUCTION PAPER AND BOARD
THOUSANDS OF SHORT TONS
200
150
100
50
0
CONSTRUCTION PAPER
CONSTRUCTION BOARD
1949
1950
1951
1952
1953
1954
SOURCE BUREAU OF THE CENSUS
CHART 20


PRODUCTION OF FOLDING BOXBOARD, SET-UP BOXBOARD, SPECIAL FOOD BOARD & MISCELLANEOUS PAPERBOARD
THOUSANDS OF SHORT TONS
300
250
200
150
100
50
0
FOLDING BOXBOARD
MISCELLANEOUS PAPERBOARD
SPECIAL FOOD BOARD
SET-UP BOXBOARD
1949
1950
1951
1952
1953
1954
SOURCE BUREAU OF THE CENSUS
CHART 25

Mathieson Activated Alum: *settles water treatment problems*

Quick-dissolving and fast-settling, Mathieson sulphate of alumina is a superior filter alum specifically designed for industrial water and wastes treatment. Its porous structure enables it to go into solution fast. The finely ground natural silicates aid coagulation, form heavier floc, and allow a greater volume to be processed in each treatment period.

In chemical plants, pulp and paper mills, petroleum refineries, Mathieson Activated Alum is providing efficient, economical water treatment and helping to solve sensitive wastes disposal problems. Mathieson's technical service staff is available for advice and practical assistance on application and handling of sulphate of alumina in all industrial installations.

See if Mathieson Chemicals can't settle your water and waste treatment problems. In addition to Activated Alum, Olin Mathieson is a major producer of chlorine, ammonia, sodium chlorite (chlorine dioxide), HTH hypochlorite products, sulphuric acid, hydrazine, caustic soda, and powdered and fused soda ash (PH-Plus). Your Mathieson representative will put you in touch with the men who can best serve you—or write today for complete information.

MATHIESON CHEMICALS

OLIN MATHIESON CHEMICAL CORPORATION

INDUSTRIAL CHEMICALS DIVISION • BALTIMORE 3, MD.

MATHIESON

3052

CAUSTIC SODA • SODA ASH • CHLORINE • SULPHURIC ACID • SULPHUR • AMMONIA • NITRATE OF SODA • BICARBONATE OF SODA • NITRIC ACID • SULPHATE OF ALUMINA • SODIUM CHLORITE PRODUCTS
ETHYLENE OXIDE • ETHYLENE GLYCOL • DIETHYLENE GLYCOL • TRIETHYLENE GLYCOL • POLYGLYCOLS • DICHLOROETHYLETHER • ETHYLENE DICHLORIDE • METHANOL • SODIUM METHYLATE • ETHYLENE DIAMINE

board mills declined 3.1% (78,000 tons) indicating that integrated mills accounted for the increased paper and board production.

The most significant market pulp development in 1954 was not the decline in consumption but the shift in the source of such pulp. Receipts of market pulp from United States pulp mills rose from 1,155,000 tons in 1953 to 1,226,000 tons in 1954, an increase of 71,000 tons, while European market pulp receipts at paper and board mills declined 135,000 tons. With the increases in United States pulp production that have occurred, market pulp consuming mills have become less dependent on overseas imports. This growing self-sufficiency on the part of the United States paper industry would be most important in times of a national emergency.

Market pulp inventories of paper and board mills at the end of 1954 showed an increase of only 15,000 tons, or 3.9% over year-end inventory for 1953. Total pulp inventories of pulp, paper and board, and non-paper mills as of Dec. 31, 1954, were 759,000 tons, an increase of 2.8% over the end of 1953.

1954 imports of wood pulp of 2,050,000 tons were 108,000 below 1953 with Canadian pulp being slightly above 1953 and, as mentioned above, European imports accounting for the decline.

Exports of wood pulp in 1954 rose to 442,000 tons, the highest level since 1940, and 280,000 tons (173%) above the 1953 exports of 162,000 tons. The increases over 1953 were in all grades with dissolving grade exports showing the largest rise, 84,000 tons.

Table XIX. Monthly Value of Sales by United States Pulp, Paper, Board, and Products Manufacturers, 1947–54 (Unadjusted)

(Millions of dollars)

Month	1954[a]	1953[b]	1952[b]	1951[b]	1950[b]	1949	1948	1947	Month	1954[a]	1953[b]	1952[b]	1951[b]	1950[b]	1949	1948	1947
January	680	695	703	714	501	458	504	458	August	742	735	668	725	645	462	519	479
February	676	690	663	686	495	432	489	449	September	734	752	674	670	616	490	521	503
March	730	711	683	775	567	476	532	469	October	764	738	740	737	673	506	532	547
April	733	739	657	743	518	438	516	482	November	734	709	657	685	670	497	498	482
May	714	724	650	774	554	422	500	494	December	712	704	655	608	658	463	473	496
June	766	741	630	732	562	432	520	474									
July	753	766	599	627	517	372	456	431	Total	8738	8704	7979	8477	6976	5448	6060	5764

[a] Preliminary. [b] Revised.
Source: Office of Business Economics. The estimated dollar total of sales represents receipts of all operators of pulp, paper, paperboard, and product manufacturing companies. The figures include data for both corporate and non-corporate businesses, but are comparable to the sales data for corporations in statistics of income published by the Bureau of Internal Revenue.

Wastepaper

The consumption of wastepaper in 1954 was 8,064,-

Table XX. Wholesale Price Index Numbers for Selected Subgroups and Classes of Wood Pulp, Paper, Paperboard, and Converted Products, and Other Selected Commodity Groups

(Index 1947–49 = 100)

Item	1954[a]	1953	1952	1951	1950	1949	1948	1947
All commodities other than farm and foods	114.5	114.0	113.0	115.9	105.0	101.3	103.4	95.3
Pulp, paper, and products group	116.3	116.1	116.6	119.6	100.9	98.5	102.9	98.6
Wood pulp subgroup	109.7	109.0	111.5	114.4	95.6	97.0	107.3	95.6
Sulphate, Southern, unbleached	102.4	97.3	109.9	120.7	88.5	89.2	112.6	98.2
Sulphate, bleached	107.9	107.9	107.9	116.3	93.9	101.5	119.1	79.5
Sulphite, bleached	112.0	112.0	112.0	112.0	98.1	98.7	104.2	97.1
Mechanical	105.2	110.0	118.1	122.1	89.6	91.5	106.7	101.8
Soda, bleached	112.9	112.9	112.9	112.9	96.5	97.9	106.1	96.0
Waste paper subgroup	80.4	90.7	70.1	188.2	119.5	61.3	90.4	148.3
Books and magazines	70.6	65.6	110.2	195.9	114.4	71.7	90.7	137 6
Folded news	84.9	98.3	67.2	148.8	114.6	65.7	91.0	143.3
Mixed paper	82.3	96.9	56.6	193.9	128.3	48.8	84.1	167.1
Corrugated	81.1	93.9	61.4	207.3	119.5	61.2	93.8	144.9
Paper subgroup	126.6	125.6	124.0	119.1	106.5	103.8	102.8	93.4
Paper, except newsprint class	125.1	123.7	123.5	120.4	106.5	103.3	103.1	93.7
Hanging	125.1	125.1	125.1	119.6	104.5	105.4	105.1	89.5
Printing paper	117.0	117.0	117.0	110.7	102.7	102.2	101.3	96.4
Bookpaper	128.4	127.4	125.8	119.8	108.5	105.2	100.7	94.1
Wood bond	120.0	118.6	117.8	115.7	105.2	103.1	104.4	92.6
Writing paper	123.8	127.1	127.1	125.1	110.5	101.4	102.3	96.4
Wrapping paper	132.3	127.5	124.5	122.3	106.7	103.1	104.8	92.1
Butcher's paper	130.9	128.6	128.1	126.8	108.5	102.7	103.2	94.1
Waxing paper	117.9	118.0	124.4	122.7	103.9	102.4	105.1	92.6
Wrapping tissue	120.7	115.7	122.8	132.2	100.0	99.4	104.9	95.7
Newsprint class	131.4	131.1	125.7	115.4	106.2	105.5	101 9	92.6
Paperboard subgroup	124.5	124.3	127.4	131.8	105.0	98.8	102.0	99.2
Container board class	119.9	117.2	115.6	117.8	102.8	100.5	100.1	99.4
Folding boxboard class	138.3	140.1	144.8	150.0	109.7	99.4	103.0	97.5
Set-up boxboard class	114.4	117.1	128.1	135.9	103.1	94.3	104.5	101.3
Converted products subgroup	112.0	112.2	113.8	116.9	97.7	97.1	102.4	100.5
Building paper and board subgroup	127.8	121.4	115.3	113.4	107.6	104.2	102.8	93.0
Fuel and power group	108.1	109.5	106.6	106.7	103.0	101.9	107.1	90.9
Chemicals and allied products group	107.1	105.7	104.5	110.1	96.3	94.8	103.8	101.4

[a] Preliminary.
Source: Prepared by the Forest Products Division, Business and Defense Services Administration, Department of Commerce, based upon data supplied by the Bureau of Labor Statistics, U. S. Department of Labor.

Improve Heat Transfer ...Reduce Maintenance

by Eliminating Corrosion

Even when an efficient deaerator removes free carbon dioxide from your system, additional CO_2 produced by decomposition of bicarbonates and carbonates remains to cause return line corrosion. Residual oxygen causes pitting. Protecting against both CO_2 and O_2 considerably reduces the cost of replacing and maintaining steam and return lines. Keeping the system free of corrosion products assures high heat transfer efficiency.

One series of Allis-Chalmers corrosion inhibitors solves this problem by neutralization. These materials are blends of the most effective amines selected according to the volatility characteristics required by each steam condensate system. Protection is provided against both CO_2 and O_2 at the points where it is needed.

Although recommendations for your specific needs can be made only after thorough analysis, you can get more information about use of this series by obtaining a copy of Allis-Chalmers Water Conditioning Informational Bulletin 50. Get a copy from your nearby A-C office or write Allis-Chalmers, Milwaukee 1, Wisconsin.

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Water Conditioning—Chemicals, Equipment, Service—for more than 25 years

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A-4606

000 tons, a decline of 5.5% from 1953 which was largely caused by the drop in paperboard production, the major user of wastepaper. Year-end inventories of wastepaper at paper and board mills for 1954 were 452,000 tons, 5.6% below inventories at the end of 1953.

Paper and Board

Paper and board production in 1954 set a new record, 12,971,000 tons in 1954, an increase of 249,000 tons over 1953. This increase more than offsets the decline in board production of 120,000 tons from 1953. Newsprint production rose to 1,192,000 tons in 1954, reflecting the production of a new southern mill and increased production in the Northeast. All other grades of paper reflected increased production in 1954, except book papers whose production dropped 63,000 tons to

Table XXI. United States Exports of Pulpwood, Wood Pulp, Paper, Paperboard, and Paper Products
(In short tons except where otherwise indicated)

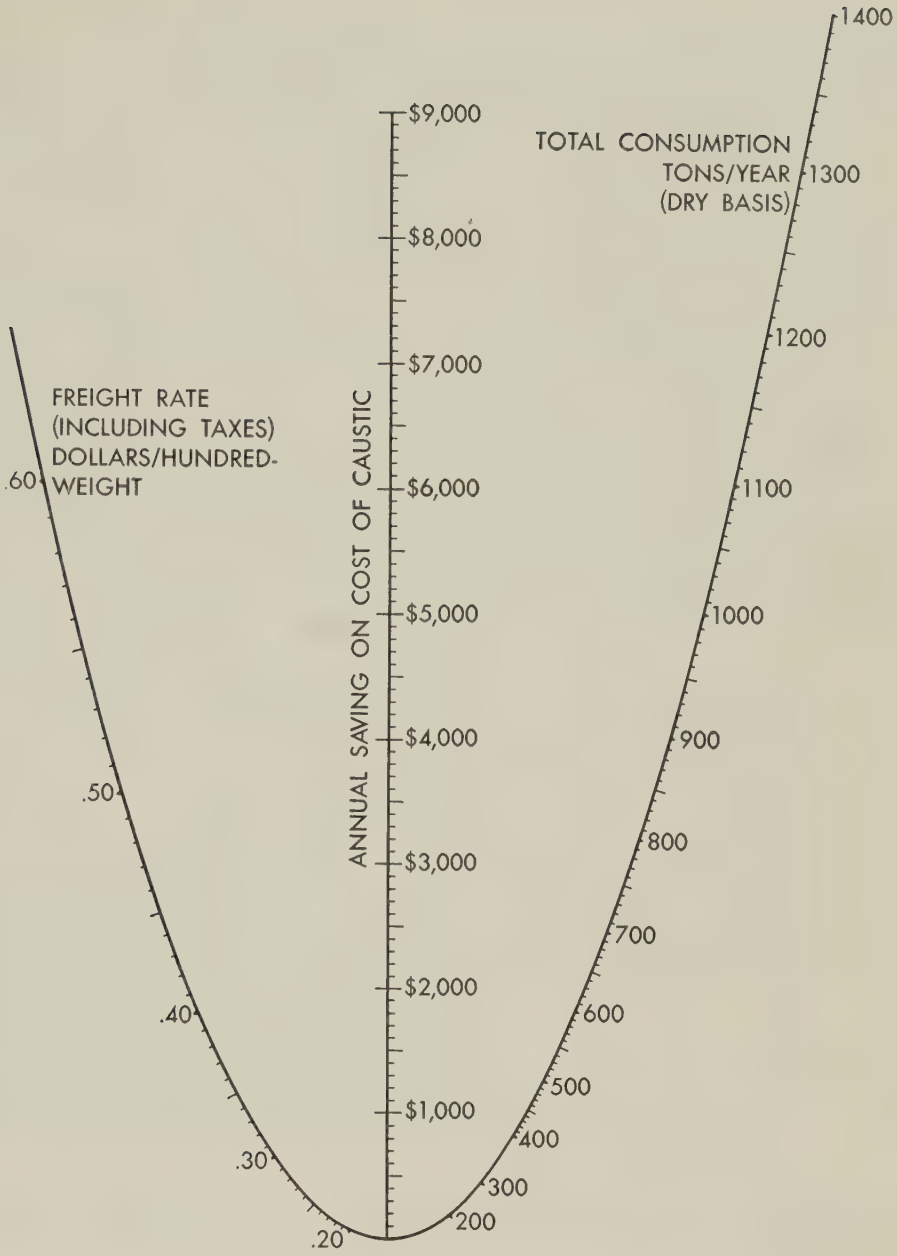
Item	*1954*[a]	*1953*	*1952*	*1951*	*1950*	*1949*
Pulpwood (in cords of 128 cu. ft.)	41,207	10,943	16,819	13,074	27,053	7,689
Wood pulp, total	441,863	161,687	211,924	199,708	95,673	122,133
Bleached sulphite: Rayon and special chemical grades	152,887	68,503	65,233	31,157	27,634	25,493
Bleached sulphite: Other	57,990	18,473	23,683	44,165	18,364	19,770
Unbleached sulphite	50,914	30,748	34,548	43,672	32,836	39,383
Bleached sulphate	99,202	13,419	11,604	9,488	4,709	9,542
Unbleached sulphate	75,104	28,830	75,864	68,464	9,555	27,234
Soda, screenings and other wood pulp	5,766	1,714	992	2,762	2,575	711
Waste fibrous materials, total[b]	126,858	114,130	142,371	206,438	119,701	117,197
Overissue news	64,217	67,538	77,824	102,383	68,495	74,265
Other waste paper and paper stock	62,641	46,592	64,547	104,055	51,206	42,932
Paper, paperboard and paper products, total	685,631	475,345	592,401	778,590	419,177	408,630
Paper and paperboard, total	590,503	382,787	499,210	527,857	297,152	294,805
Paper, total	326,466	189,013	325,566	277,124	175,127	180,980
Newsprint	140,395	46,675	104,998	71,295	43,966	38,660
Groundwood printing paper, total	12,361	6,317	35,419	19,618	7,766	7,299
Uncoated	7,788	4,590	31,027	15,842	5,823	4,405
Coated	4,573	1,727	4,392	3,776	1,943	2,894
Book paper, total	28,195	20,247	30,452	32,419	19,207	32,876
Uncoated	15,948	11,657	17,115	17,957	14,300	28,231
Coated	12,247	8,590	13,337	14,462	4,907	4,645
Fine paper, total	40,696	33,899	40,450	47,776	38,535	43,656
Writing paper	29,243	24,014	32,128	35,246	29,801	32,901
Cover paper	818	881	920	810	547	[d]
Bristols	1,161	926	911	1,409	1,071	1,034
Cigarette paper	8,465	7,134	5,501	8,790	6,580	8,327
Other fine	1,009	944	990	1,521	536	1,688
Wrapping, bag and converting paper, total	50,590	33,129	58,596	56,511	28,354	29,583
Kraft	41,529	26,208	47,891	40,797	17,025	19,173
Greaseproof and waterproof paper[c]	2,486	4,794	2,853	5,489	3,843	3,297
Other paper	6,575	2,127	7,852	10,225	7,486	7,113
Shipping sack paper	22,621	20,641	29,793	20,001	11,488	1,369
Special industrial	11,507	10,740	10,139	9,337	7,325	5,578
Sanitary tissue paper stock	2,846	2,564	1,580	2,779	5,345	6,961
Tissue paper	4,318	3,147	3,693	4,518	2,088	3,017
Absorbent paper	3,241	2,950	2,620	2,854	2,731	2,762
Building paper	9,696	8,704	7,826	10,016	8,322	9,219
Paperboard, total	264,037	193,774	173,644	250,733	122,025	113,825
Container board (liners and corrugating)	169,746	110,349	92,851	134,613	59,940	49,900
Boxboard (bending and nonbending)	33,590	37,320	23,129	50,040	14,944	20,105
Other paperboard	28,933	3,239	8,549	26,482	15,424	10,691
Fiber insulation board	18,072	17,167	16,515	20,210	15,700	18,872
Wallboard	5,067	4,267	8,222	4,749	7,763	5,679
Cardboard	8,629	21,432	24,378	14,639	8,254	8,578
Paper products, total	95,128	92,558	93,191	107,406	74,364	77,417
Surfaced-coated paper[d]	...	...	...	...	...	...
Toilet paper	9,943	10,331	7,917	9,406	7,383	8,046
Paper towels and napkins	3,485	1,599	2,757	2,736	1,972	1,867
Filing folders, index cards and other office forms	3,895	3,941	3,483	3,699	3,772	2,636
Papeteries	[d]	[d]	[d]	407	359	366
Wallpaper	198	176	280	258	206	205
Shipping sacks	12,992	8,946	12,985	19,803	10,128	5,716
Paper bags	4,040	4,833	5,296	6,462	7,101	10,293
Shipping containers	12,992	13,407	15,230	14,867	7,795	9,822
Boxes and cartons	7,468	8,567	10,021	9,688	5,247	5,365
Envelopes	501	482	552	525	502	700
Cash register and adding machine paper[d]	...	...	...	...	...	...
Other paper and paper products	39,614	40,276	34,670	39,555	29,899	32,401

[a] Preliminary. [b] Excludes rags for paper stock (code deleted July 1953). [c] Includes glassine and vegetable parchment. [d] Not shown separately.
Source: Prepared by the Forest Products Division—Business and Defense Services Administration, based upon data from the Bureau of the Census, U. S. Department of Commerce.

with 26,657,000 tons, surging ahead of 1953, principally the result of the high activity during November and December, 1954. A year ago estimates of 1954 production ranged from 5 to 10% below 1953, and even as late as the fall of 1954 production was expected to be 1 to 3% below 1953.

Paper production, including building paper, was 1,560,000 tons in 1954 and special industrial papers which declined 28,000 tons.

The decline in over-all board production, including building boards, in 1954 to 13,686,000 tons from 13,806,000 tons in 1953 is attributable mainly to the drop in containerboard production to 6,432,000 tons from the 1953 record level of 6,613,000 tons. Folding boxboard



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This figure represents your savings on freight charges after the $2.00 premium price on 73% caustic soda has been deducted.

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"CAUSTIC SODA BUYER'S GUIDE" is the title of a new pocket-size booklet we'll be glad to send you free. Contains helpful facts on the economics of 50% and 73% solutions; other forms of caustic soda; capacities of tank cars and other containers; useful shipping information. Write us for a copy.

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Table XXII. United States Imports of Pulpwood, Wood Pulp, Paper, Paperboard, and Paper Products

(In short tons, except where otherwise indicated)

Item	1954[a]	1953	1952	1951	1950	1949	1948
Pulpwood, total (in cords of 128 cu. ft.)	1,602,978	1,552,340	2,124,880	2,511,401	1,412,365	1,418,468	2,020,979
Rough	428,370	453,745	820,275	883,390	373,460	510,134	913,838
Peeled	775,549	776,616	1,036,959	1,406,937	844,781	791,325	1,010,993
Rossed	559	5,603	3,142	3,931	151	447	806
Chipped	398,500	316,376	264,504	217,143	153,973	116,562	95,342
Wood pulp, total	2,050,760	2,157,574	1,936,687	2,360,734	2,384,975	1,763,102	2,176,111
Bleached sulphite: Rayon and special chemical grades	230,384	255,523	222,608	230,800	238,846	153,946	235,481
Bleached sulphite: other	288,396	333,538	276,698	348,541	401,776	331,288	322,830
Unbleached sulphite	339,418	380,397	431,678	557,357	528,673	392,222	674,707
Bleached sulphate	637,193	590,224	519,035	521,560	450,352	391,609	277,989
Unbleached sulphate	269,852	292,593	207,871	335,573	440,378	248,814	336,449
Soda pulp	37,936	34,958	28,073	33,373	33,947	27,315	24,843
Chemical screenings	[d]	6,688	4,260	10,344	4,695	3,163	8,275
Bleached mechanical groundwood	62,830	65,255	34,341	17,675	20,202	593	...
Unbleached mechanical groundwood	173,731	194,103	207,899	300,418	260,347	208,224	290,984
Mechanical groundwood screenings	11,020	4,295	4,224	5,093	5,759	5,928	4,553
Waste fibrous materials, total	50,434	65,334	78,825	116,500	131,147	72,055	102,845
Rags for paper stock	3,949	5,165	7,528	20,219	25,300	7,917	20,040
Other pulp-rag, straw, esparto, etc.	137	443	217	254	88	[b]	4
Other waste fibrous materials	46,348	59,726	71,080	96,037	105,767	64,138	82,801
Paper, paperboard and paper products, total	5,187,317	5,231,326	5,191,126	5,152,322	5,007,384	4,751,323	4,581,811
Paper and paperboard, total	5,169,018	5,212,819	5,173,352	5,139,254	4,998,347	4,746,248	4,575,095
Paper, total	5,070,130	5,088,777	5,089,593	5,024,870	4,912,974	4,676,126	4,499,682
Newsprint	4,992,089	5,004,050	5,033,014	4,962,562	4,862,995	4,639,562	4,395,572
Printing paper, uncoated	35,783	41,450	42,984	47,326	35,278	28,281	83,379
Fine paper, total	2,387	3,344	1,314	1,333	1,229	640	1,537
Writing paper	602	90	79	74	115	37	120
Cover paper	...	5	...	[b]	[b]	[b]	3
Bristols	315	446	156	258	259	93	12
Thin paper	1,348	2,645	952	799	710	419	1,344
Other fine paper	122	158	127	202	145	91	58
Wrapping, bag, and converting paper, total	36,188	35,328	10,331	11,079	10,864	5,712	18,420
Kraft wrapping[c]	29,144	29,253	8,656	6,876	7,330	3,823	10,628
Greaseproof and waterproof paper	2,880	1,769	564	2,130	1,148	22	48
Wrapping, except kraft[c]	4,164	4,306	1,111	2,073	2,386	1,867	7,744
Tissue and crepe paper	1,751	716	266	223	452	1,352	376
Absorbent paper	167	127	129	94	101	122	92
Building paper	1,765	3,762	1,555	2,253	2,055	457	306
Paperboard, total	98,888	124,042	83,759	114,384	85,373	70,122	75,413
Kraft container board	22,373	33,325	4,385	967	...	...	...
Other container and boxboard	117	375	175	1,739	465	3	629
Other paperboard	55,843	64,656	52,419	78,416	54,179	47,769	44,015
Fiber insulation board	4,138	5,245	3,824	3,015	3,319	275	400
Wallboard	16,417	20,441	22,956	30,247	27,410	22,075	30,369
Paper products, total	18,299	18,507	17,774	13,068	9,037	5,075	6,716
Papetries	84	139	219	133	155	73	38
Surface-coated papers	1,401	1,055	2,404	1,002	265	40	32
Uncoated papers, decorated or covered with a design, etc.	28	64	78	103	25	1	7
Wallpaper	4,034	3,224	2,879	2,303	2,638	1,365	1,259
Decalcomania paper	633	776	608	1,277	1,110	619	957
Paper, paperboard and paper products—Con.							
Paper products—Con.							
Boxes of paper, papier-mache, or paperboard (not covered or lined)	744	810	1,119	543	479	357	300
Boxes of paper, papier-mache, or wood (covered or lines)	243	95	204	96	67	41	27
Manufacturers of papier-mache, n.s.p.f.	225	198	163	154	106	58	51
Manufacturers of pulp, n.s.p.f.	97	87	78	268	96	51	52
Bags and articles of surface-coated, parchment, or similar papers	191	283	229	181	168	56	63
Albums, photograph, autograph, scrap, etc.	4	3	4	2	6	2	3
Envelopes	139	137	182	126	47	47	40
Jacquard designs	...	1	[b]	...	[b]	[b]	...
Gummed paper, n.s.p.f.	64	30	9	211	19	[b]	1
Tubes for holding yarn and thread	134	89	54	69	22	[b]	...
Wall pockets of paper, papier-mache, etc.	...	21	28	38	37	3	1
Ribbon flycatchers	290	204	83	44	115	...	9
Masks of paper, pulp or papier-mache	24	29	30	31	8	6	...
Reinforced or cloth-lined paper	2	3	[b]	[b]	[b]	[b]	...
Stencil paper, not mounted	...	1	[b]	4	2	1	1
Papers, n.s.p.f.	2,569	2,866	2,185	1,729	1,133	400	652
Manufacturers of paper, n.e.s.	7,393	8,392	7,218	4,754	2,593	1,955	3,223

[a] Preliminary. [b] Less than one-half short ton. [c] Includes bag paper. Conversion factors derived from reported gross shipping weights. Stereotype matrix mat or board (included under absorbent paper)—1000 sq. in. = 1.43 lb.; papeteries—$500 = 1 ton. Boxes of paper, papier-mache, or paperboard (not covered or lined)—$140 = 1 ton. Manufacturers of papier-mache, n.s.p.f. —$2.240 = 1 ton. Manufacturers of pulp, n.s.p.f.—$860 = 1 ton. Albums, photograph, autograph, scrap, etc.—$3,060 = 1 ton. Jacquard designs on ruled paper, etc. –$94,000 = 1 ton (price includes cost of die). Ribbon flycatchers —$840 = 1 ton. Masks of paper, pulp, etc.—$760 = 1 ton. Papers, n.s.p.f.—$80 = 1 ton. Manufacturers of paper, n.e.s.—$360 = 1 ton. Wall pockets of paper, papier-mache, etc.—10,000 wall pockets = 1 ton. [d] Included in mechanical groundwood screenings.

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and building board showed production gains in 1954 over 1953 levels, but the other grades of board, such as special food board, set-up boxboard, and miscellaneous paperboard showed declines when comparing 1954 production with 1953.

Wholesale Trade

Wholesale paper merchant sales in 1954 also reached a record level being 2.7 billion dollars, 3.6% above the 1953 sales. Inventories dropped 6.4% to 249 million dollars, reflecting the desire of merchants to keep stock at reasonable levels consistent with their ability to obtain needed supplies from the paper mills. Commerce field officers report that wholesale merchants generally have been able to keep prices steady although there is strong competition, which has been not so much price-wise but rather in better customer service.

Imports

Wood pulp imports trends have been analyzed under the previous section on wood pulp.

Paper and paperboard imports in 1954 totaled 5,169,000 tons, a decline of 44,000 tons from the 1953 level. Newsprint accounting for all but 78,000 tons of the total paper showed a minor drop of 12,000 tons. All other grades of paper except writing paper, greaseproof and waterproof papers, and tissue paper, registered small decreases in 1954 when compared with 1953. Greaseproof and waterproof paper imports in 1954 were 2880 tons, an increase of 1111 tons over 1953, and 2316 tons over 1952 imports. Imports of tissue and crepe paper in 1954 were 1751 tons, an increase of over 1000 tons over 1953.

Paperboard imports declined 25,000 tons in 1954 when compared with 1953, with container board accounting for 11,000 tons of the drop.

Imports of paper and paperboard products were virtually the same as in 1953 with no significant shifts among the various types.

Exports

Exports of wood pulp at 442,000 tons in 1954 were 280,000 tons above the 1953 level and indicated that the United States is actively becoming a major supplier of wood pulp to world markets.

Paper exports increased from 189,000 tons in 1953 to 326,000 tons in 1954, with newsprint increasing from 47,000 tons to 140,000 tons, kraft papers rising from 26,000 tons in 1953 to 41,000 tons in 1954. Other grades of paper showed less significant increases in export during 1954.

Paperboard exports in 1954 at 264,000 tons were 70,000 tons above 1953, with container board showing the largest increase (60,000 tons) as 1954 exports were 170,000 tons and 1953 exports 110,000 tons. The 1954 level of 170,000 tons was 120,000 tons over 1949.

Paper and paperboard products showed a minor increase in exports in 1954 when compared with 1953, with the increase of 2600 tons being the result of minor shifts in the various items included in this group.

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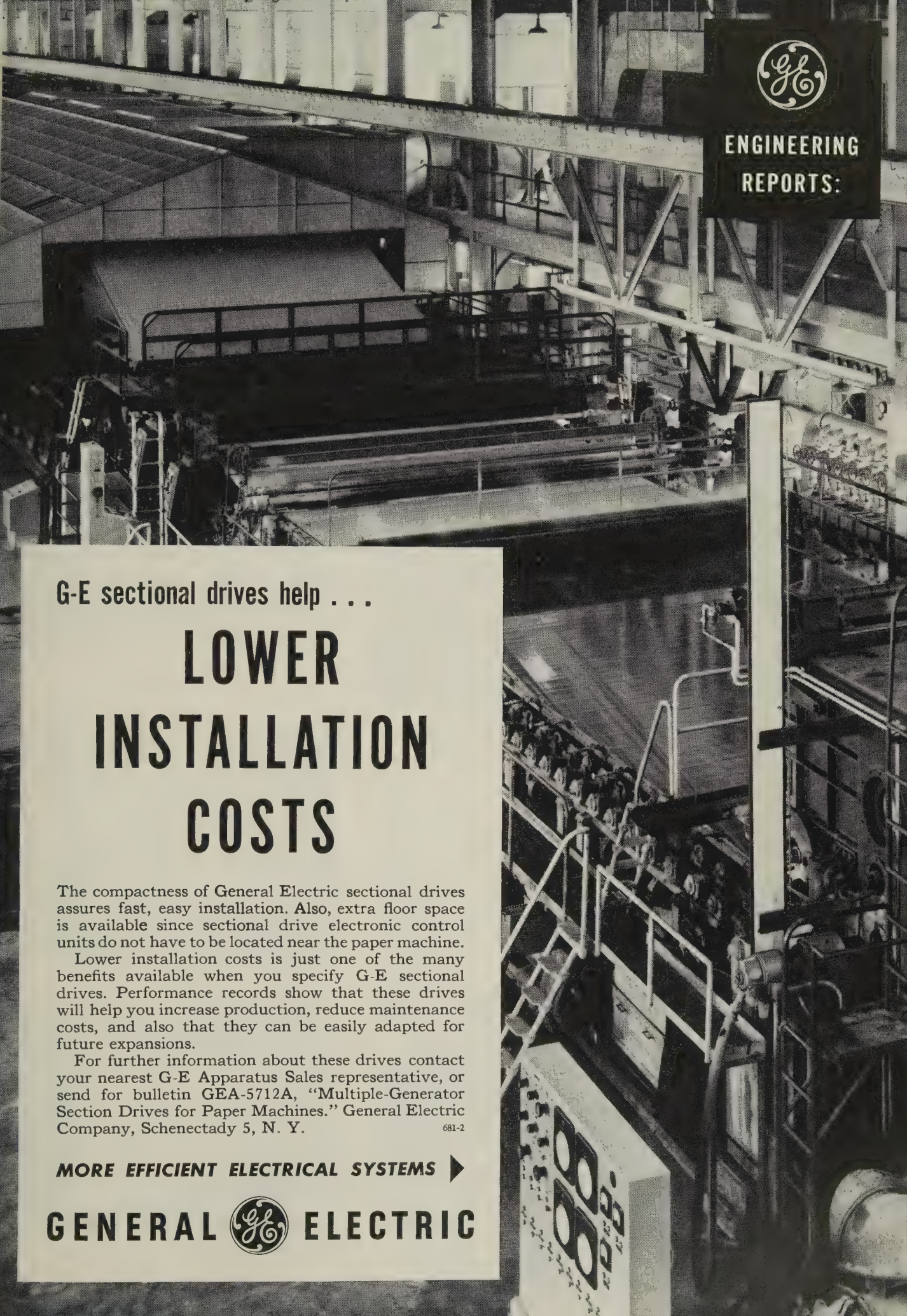

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For further information about these drives contact your nearest G-E Apparatus Sales representative, or send for bulletin GEA-5712A, "Multiple-Generator Section Drives for Paper Machines." General Electric Company, Schenectady 5, N. Y. 681-2

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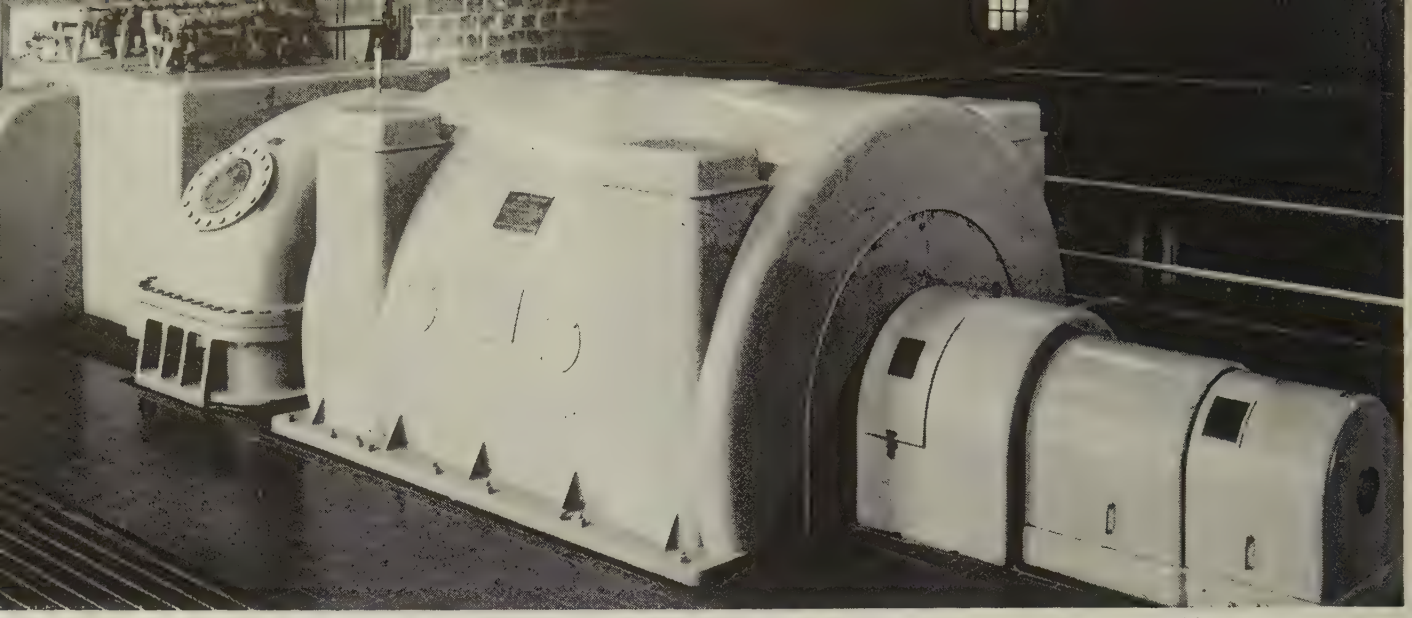

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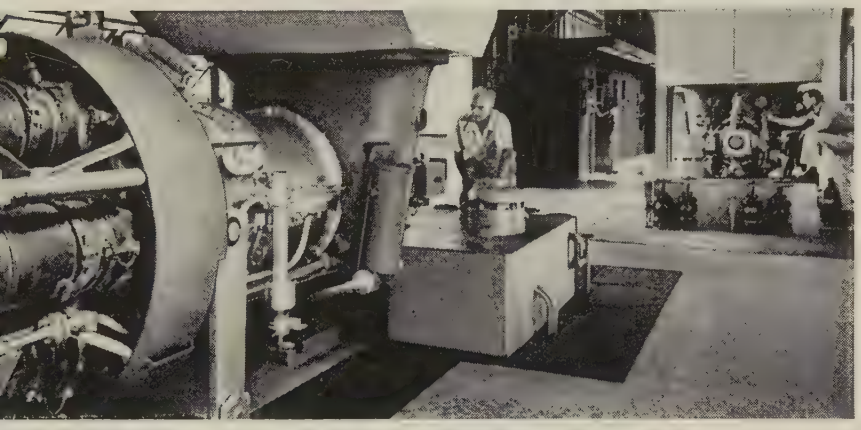

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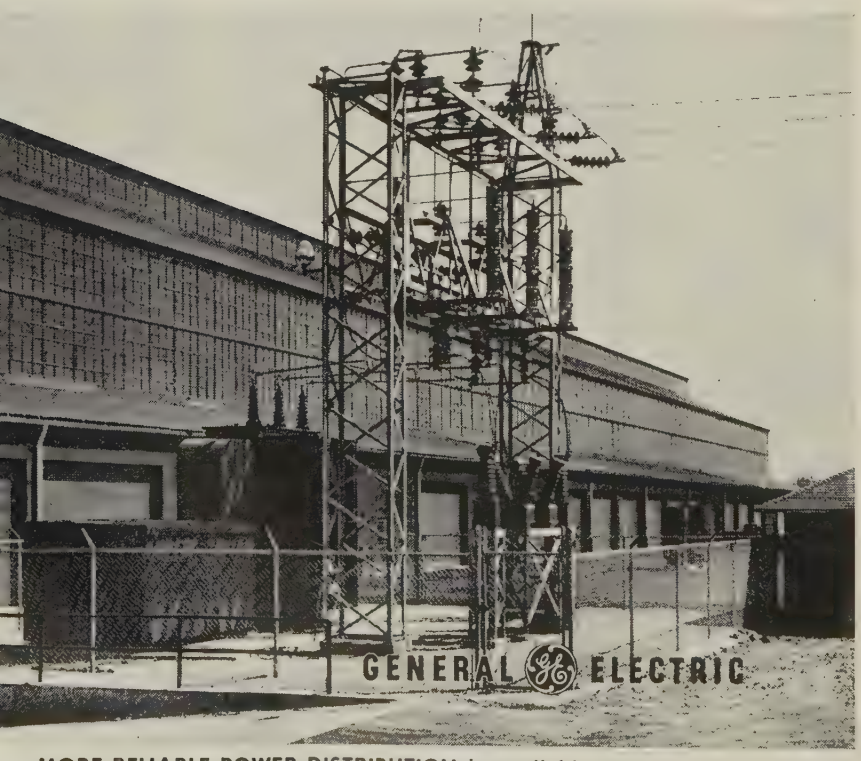
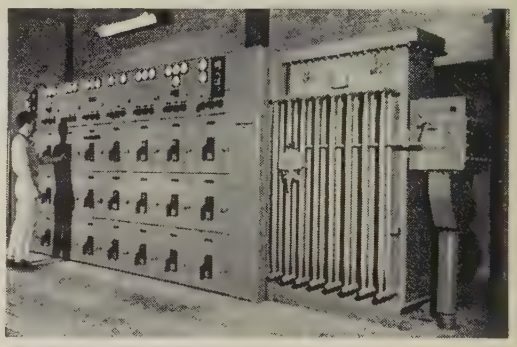
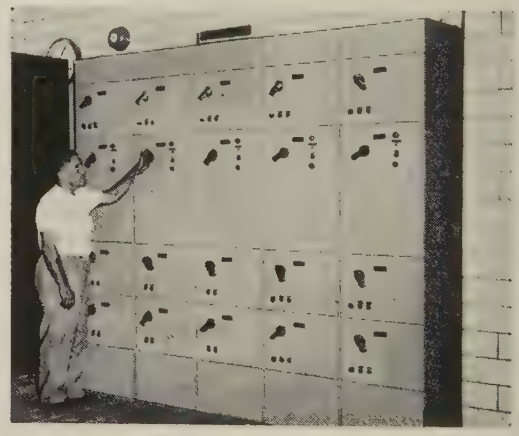


MORE RELIABLE POWER DISTRIBUTION is available with G-E package substations which use co-ordinator transformers, metal-clad switchgear.



FACTORY ASSEMBLED G-E load center unit substations help cut installation time.



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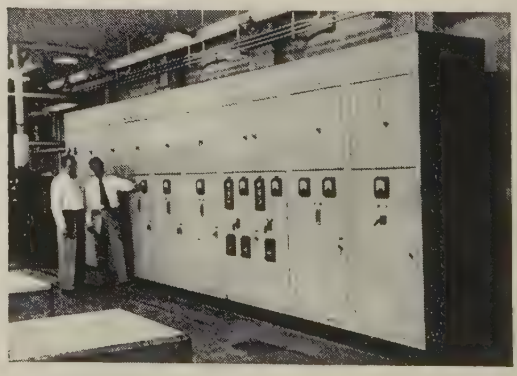

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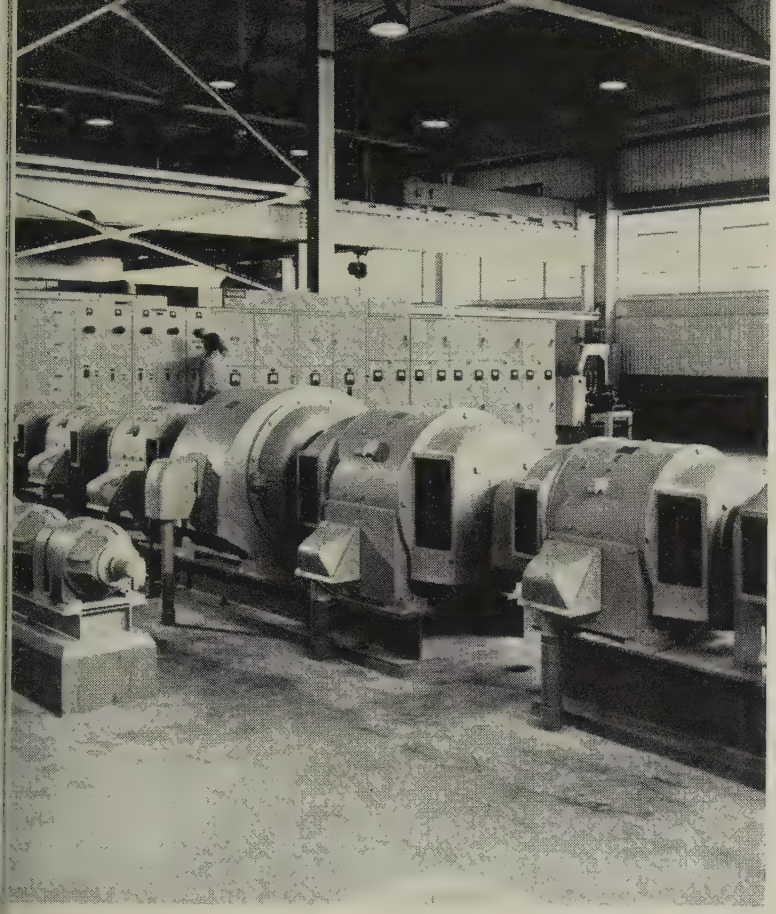

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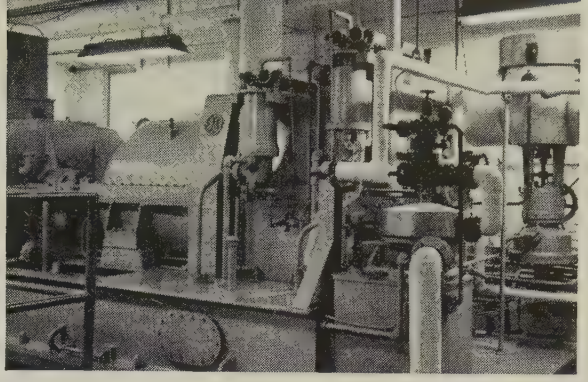
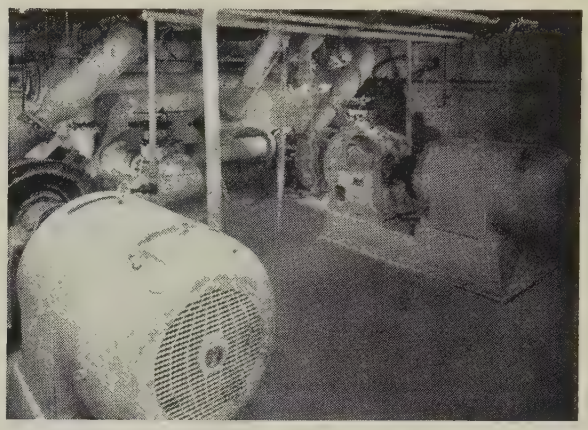


ECONOMICAL MAINTENANCE is a key feature in design of G-E mechanical drive turbines.



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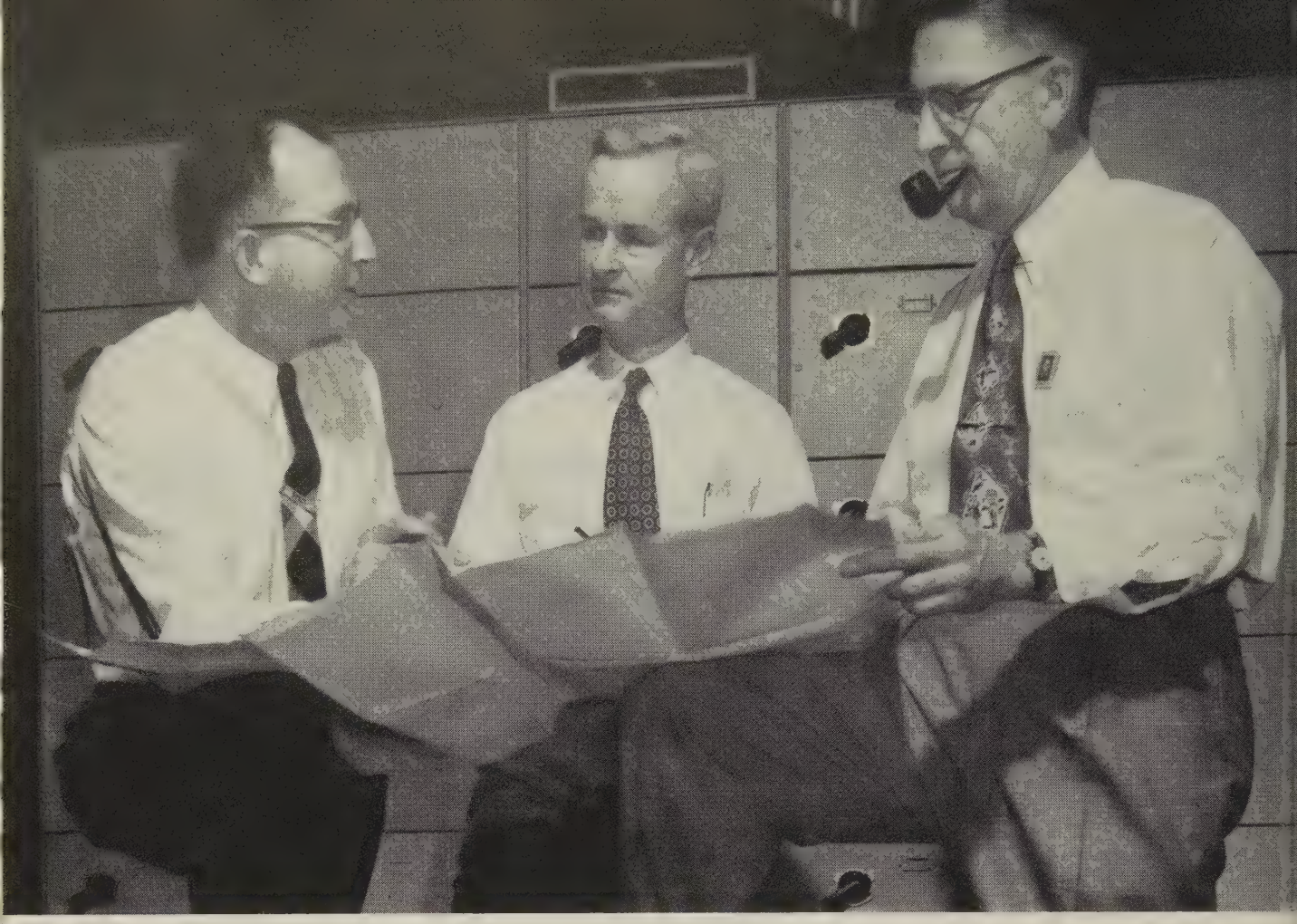

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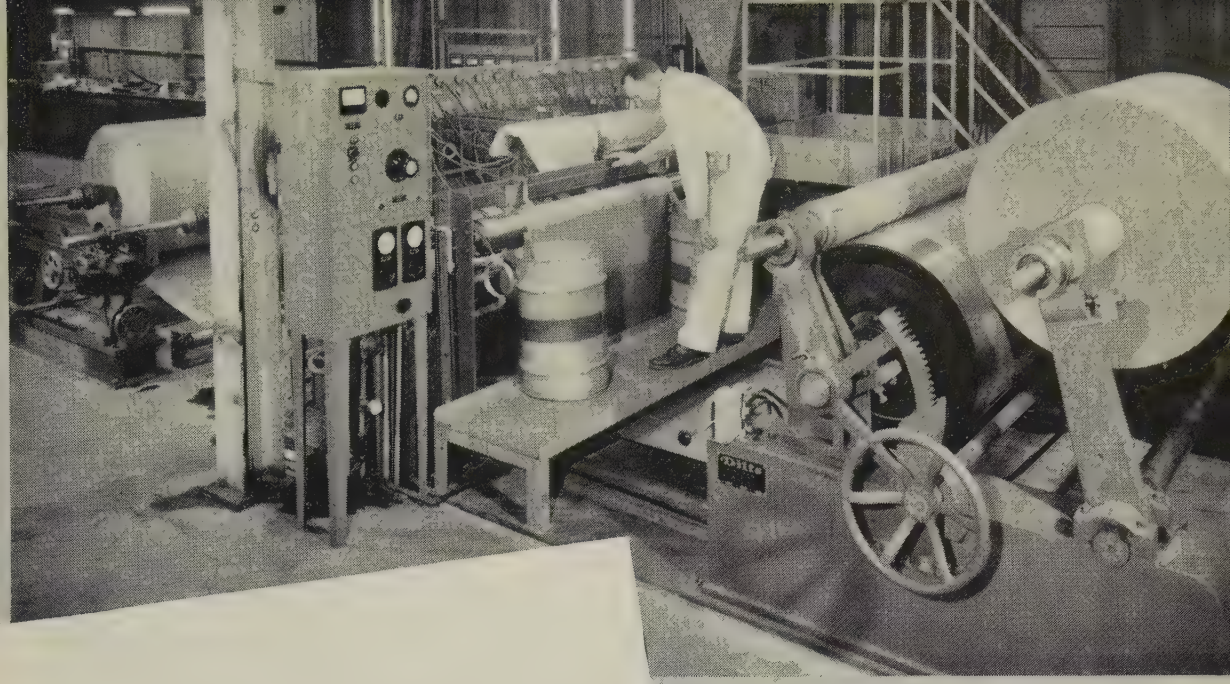

Guardian paper company

4246 HOLLIS STREET, OAKLAND 8, CALIFORNIA PIEDMONT 5-6446

December 8, 1954

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Dilts Machine Works Div.
Fulton, New York

Attention of: Mr. R. J. Jacobs

Dear Bob:

We are extremely pleased with the extruder laminator you built for us. We put the unit into operation last month and within a few days had an excellent salable paper. We are appreciative of the many engineering details incorporated in the machine.

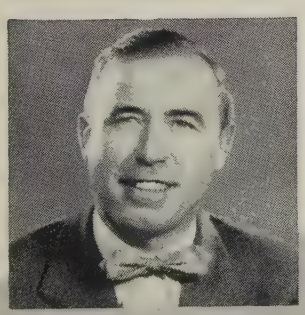
We erected the machinery with local men who were not experienced paper-machine people, and the component parts went together without a hitch. We did not send out any pieces for machining, drilling or change in any way.

We wish to thank you and the engineers in your organization for the excellent start they have given this new company.

Sincerely yours,

Thomas C. Sewell

TCS/jkl



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A New Company off to a Flying Start with a Dilts Polyethylene Extruder-Laminator

The Guardian Paper Company, Oakland, California, began operations with the highly successful start-up of this polyethylene extruder-laminator line engineered for them by Dilts.

By selecting the proper combination of standard units, Dilts engineers furnished a complete package installation . . . an efficient, economical machine line designed to best meet the new firm's specific production requirements.

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PULPWOOD INDUSTRY FACTS*

Wood is the chief raw material for newspapers, milk containers, rayon, photographic film, business forms, shipping cartons and bags, and a host of other useful items. Our demand for these products has pushed pulp and paper processing into fifth place among the industries of the nation. If the manufacture of pulp and paper were suddenly stopped, life in these United States in a matter of days would be thrown into utter confusion and many of our economic processes would cease altogether.

More than 90% of the pulp and paper manufactured in the United States is made from wood. Most of this wood comes from our 460,452,000 acres of commercial forest land. The rest is imported, chiefly from Canada.

The pulpwood industry is that industry which grows and harvests pulpwood and transports it from the forests to the pulp mills over distances up to more than 300 miles. It is a business that reaches into most every forested section of the country; one in which over 30,000 independent operators employ hundreds of thousands of men and use enormous amounts of tools, equipment, and supplies.

The statistics contained in this review were compiled from a variety of industry and government sources. The American Pulpwood Association was especially helpful in furnishing data. Here in capsule form is the basic information on the nature, size, importance, and future of America's pulpwood industry.

WHAT PULPWOOD IS

Pulpwood is wood that has been cut or prepared primarily for processing into pulp, which in turn is manufactured into paper, paperboard, plastics, and other products. Most of the wood comes to the pulp mills usually cut 4 to 8 ft. in length from trees 4 to 14 in. in diameter. Because bark cannot be used in paper manufacture most pulpwood is peeled. The peeling is done in the woods by the loggers or at the mill by machines, and sometimes by applying chemicals to the standing live trees. When the pulpwood is not peeled before processing, the bark is separated from the wood fibers in the early stages of pulpmaking.

The common unit of measure of pulpwood is the standard cord—a stack of 4-ft. sticks piled 4 ft. high and 8 ft. long. Theoretically, such a stack contains 128 cu. ft., but actually it contains much less solid wood due to the irregular shapes of the pieces in the pile, and the thickness of their bark. Sometimes pulpwood is purchased on a basis of weight, the unit of measurement being the ton of 2000 lb.

Pulpwood weighs from $1^1/_2$ to 3 tons a cord, depending on the species, the amount of solid wood in the stack, and the amount of moisture in the wood. In most pulpwood regions a truckload of pulpwood consists of 2 to 8 cords. A freight car load is 12 to 30 cords.

The amount of pulp obtainable from a cord of pulpwood depends on the species, the amount of solid wood in the cord, the pulping process used, and the efficiency of the mill. For the United States as a whole 1.6 cords of pulpwood are required to make a ton of wood pulp, which in turn will make, on the average, 0.9 ton of paper or paperboard.

There is considerable variation in the length of pulpwood sticks common to the different pulpwood-producing regions, but practically all purchases are based on the standard cord regardless of the length of stick cut. In the Appalachian region the common length is 5 ft., but some is 4 ft.; in the Southern region east of the Mississippi River the common size is 5 ft. 3 in., and west of the river it is 5 ft. In the Northeastern States most sticks are cut to 4 ft., but some are 50 or 52 in. In the Lake States the usual length is 100 in., while in the West various log lengths up to 40 ft. are common to the larger operations, although "farmer wood" cut from woodlots is 8 ft.

Some pulpwood received at the mills is material left over from sawmill or plywood mill operations in the form of slabs, edgings, veneer cores, and other material formerly not usable except for fuel. The use of these leftovers is increasing rapidly in all sections of the country. More and more sawmills are installing barking machines to remove the bark from their sawlogs before sawing in order to make the slabs and edgings usable as pulpwood.

Nearly all common forest tree species are used to some extent. Softwoods, or conifers—pine, spruce, hemlock, and fir, for example—are the most commonly used, but hardwoods—oak, aspen, maple, and gum, to name a few—are coming into wider use. Spruce was the first wood to be used in pulpmaking; then later, processes were developed to utilize other softwood and hardwood species. At the present about 86% of the pulpwood is softwood.

Wood is converted to pulp by first reducing the pulpwood to chips or finely ground bits, which are then cooked or otherwise processed to separate the wood fibers from the other components. The fibers are then beaten to separate them and to reduce them to proper length. During the beating process materials for coloring and sizing may be added. The liquid containing the wood fibers is run over an endless wire mesh screen and the water is removed, leaving a sheet of pulp.

PULPWOOD PRODUCTION IN THE UNITED STATES

Pulpwood is produced in nearly every forested section of the country. The proportion of domestically produced pulpwood has been steadily rising over the

* Prepared by the American Forest Products Industries, Inc., Washington, D. C.

● Early 18th Century Chinese Plate with Yang-Yin symbol in the center. From the collection of Captain and Mrs. H. F. D. Davis, now owned by Mrs. H. N. Hill.

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This symbol (Yang-Yin) represents T'ai-chi, the old Chinese *Ultimate Principle*, and as such, *perfection*.

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years. Table I gives an idea of United States pulpwood production since 1941:

Table I

Year	Cords received at mills	Produced in U. S. — Cords	Produced in U. S. — Per cent of total	Imported — Cords	Imported — Per cent of total
1941	16,458,000	14,177,000	86	2,281,000	14
1943	15,293,000	13,581,000	89	1,712,000	11
1945	16,983,000	15,254,000	90	1,729,000	10
1947	20,613,000	18,529,000	90	2,084,000	10
1949	19,252,000	17,547,000	91	1,706,000	9
1951	27,778,000	25,128,000	90	2,650,000	10
1953	27,887,000	26,339,000	94	1,548,000	6

Most of the pulpwood comes from small ownerships and farm woodlots owned by more than 4,222,000 persons. It is probable that the number of people who grow and sell pulpwood in the nation runs into the millions.

Pulp and paper companies own and lease lands which produce pulpwood and other forest products, while the governments—federal, state, and local—produce small amounts on forest lands which they own or manage.

Table II. Pulpwood Production by Ownership of Land[a]

Ownership	Commercial forest, acres	Per cent of total	Cords produced	Per cent of total
Pulp and paper company lands	27,823,000	6.1	3,618,508	13.7
National forests	73,543,000	16.0	822,000	3.1
State forests	21,856,000	4.7	441,000	1.7
Other lands	337,230,000	73.2	21,594,492	81.5
All ownerships	460,452,000	100.0	26,476,000	100.0

[a] Based on 1952 production.

Pulp and paper company lands, which comprise only slightly more than 6% of the commercial forest land of the United States, accounted for nearly 14% of the pulpwood production. National and state forests—comprising more than 20% of the commercial forest lands—produced only 5% of the pulpwood. Farm woodlots, other private forests, and government forests not included in the national and state forest* which account for less than three-quarters of the nation's commercial forest, produced more than four-fifths of the pulpwood.

THE PULPWOOD PRODUCING REGIONS OF THE UNITED STATES

There are five recognized pulpwood-producing regions which correspond roughly to the principal forest regions of the United States. Each region is characterized by its own conditions of species produced, methods of production, and other features. The locations of these regions are shown in Fig. 1.

Appalachian Region

The northern forests of spruce and fir and northern and central hardwoods characterize this region, with hardwoods predominating. The principal species of pulpwood produced are oak, maple, pine, gum, beech, and poplar. Approximately 60% of the pulpwood output of the region is produced by farmers.

Southern Region

Extensive forests of pine are characteristic of the southern region, but there are also some areas of fine hardwoods. Nearly 90% of the pulpwood produced in this region is pine. Here most of it is obtained from outside of company-owned or leased lands, about 70% being harvested from farm woodlots and other small forest properties. The use of sawmill leftovers is increasing at the southern mills.

Northeastern Region

The first pulpwood produced in the United States was cut from spruce forests of this region. Spruce—white and red—balsam fir, hemlock, pine, birch, maple, oak, poplar, and cherry are the principal species produced. About 30 to 50% of the pulpwood is produced by farmers. More peeling is done in the woods in this region than in any other, but still more than half is peeled at the mill.

Lake States Region

The extensive forests of spruce drew the pulp and paper industry to the Lake States, and this species still accounts for a fairly large portion of the pulpwood produced there. Other softwood species—balsam fir, pine, hemlock, and tamarack—are also produced. The production of aspen plupwood in this region, which started in the 1930's, is on the increase and in 1953 accounted for about 45% of the total production of the three states. About half the production is by farmers.

Western Region

The extensive old-growth forests of the northwest and the vigorous young stands which follow harvesting of the old timber, yield large quantities of Douglas-fir, western hemlock, white fir, and spruce pulpwood. It is in this region that the practice of making pulp from the leftovers of sawmilling and woods operations is most widely adopted. Even though the goverments own half of the commercial forest land in the region, still the major portion of the pulpwood produced comes from private lands. A small amount is purchased from farmers.

THE PULPWOOD INDUSTRY IN THE UNITED STATES ECONOMY

Along with pulp companies more than 30,000 small business operators, variously called pulpwood producers, contractors, and loggers, are engaged in the cutting, bucking, peeling, and transporting to the mills of around 27,000,000 cords of pulpwood each year. As independent business men they employ, altogether, thousands of workers. The average operation employs from five to ten men.

The harvesting of pulpwood provides an important source of employment to farmers and others living in rural communities during periods when other work is slack. For the United States as a whole, the persons engaged in the pulpwood industry each worked an average of 8.3 months a year in pulpwood operations. At least 250,000 woods workers are now employed annually on a part-time basis.

* County and community forests, public school forests, and other federal and state forest lands.

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By working together, paper makers and converters may upgrade sheets—prior to converting—with emulsifiable A-C POLYETHYLENE. Then, by altering the coating weight of the hot melt, new grades, new finishes, new papers might result.

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The delivery to the mills of 27,000,000 cords of pulpwood, weighing approximately 50 million tons, and transporting men to and from the woods, cutting down, bucking the fallen trees into the desired lengths, splitting the larger logs, peeling the bark in the woods or at the mill, and handling in the mill storage yard—all these operations require large quantities of tools and equipment, and fuel to run the machinery. The American Pulpwood Association estimates the requirements of tools and equipment for pulpwood production in a recent year as follows:

Hand axes	130,000
Hand saws	100,000
Power saws	25,000
Tractors	7,000
Trucks	31,000
Trailers	2,600
Cranes and shovels	500
Logging sulkies and arches	500
Loaders	1,000
Road graders	490
Snow plows	700

To operate the vast army of mechanized equipment used each year in the pulpwood industry it is estimated from 60 to 80 million gal. of gasoline and other liquid fuels are consumed.

PULPWOOD CONSUMPTION IN THE UNITED STATES

The United States uses more paper and paperboard than any other nation in the world. Since wood came into common use in the making of paper—around 1880—the per capita consumption of pulpwood in this country has increased sevenfold. Today per capita consumption stands at nearly 800 lb. of wood a year.

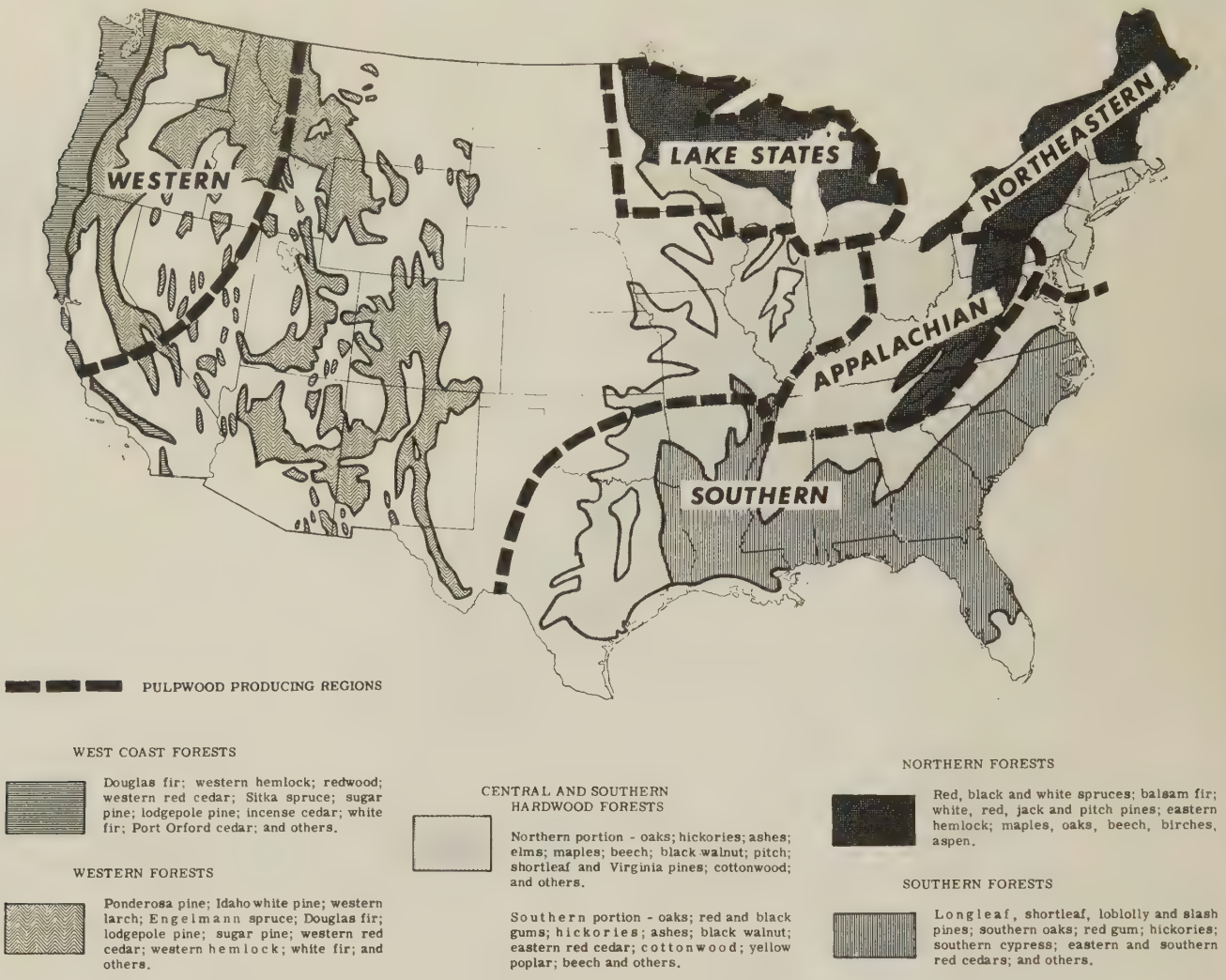
WESTERN
LAKE STATES
NORTHEASTERN
APPALACHIAN
SOUTHERN
PULPWOOD PRODUCING REGIONS
WEST COAST FORESTS
Douglas fir; western hemlock; redwood; western red cedar; Sitka spruce; sugar pine; lodgepole pine; incense cedar; white fir; Port Orford cedar; and others.
WESTERN FORESTS
Ponderosa pine; Idaho white pine; western larch; Engelmann spruce; Douglas fir; lodgepole pine; sugar pine; western red cedar; western hemlock; white fir; and others.
CENTRAL AND SOUTHERN HARDWOOD FORESTS
Northern portion - oaks; hickories; ashes; elms; maples; beech; black walnut; pitch; shortleaf and Virginia pines; cottonwood; and others.
Southern portion - oaks; red and black gums; hickories; ashes; black walnut; eastern red cedar; cottonwood; yellow poplar; beech and others.
NORTHERN FORESTS
Red, black and white spruces; balsam fir; white, red, jack and pitch pines; eastern hemlock; maples, oaks, beech, birches, aspen.
SOUTHERN FORESTS
Longleaf, shortleaf, loblolly and slash pines; southern oaks; red gum; hickories; southern cypress; eastern and southern red cedars; and others.

Fig. 1. Pulpwood producing regions and forest regions of the United States

Table III. Per Capita Consumption of Pulpwood in the United States

Year	*Pulpwood consumed, cord*	*Population*	*Per capita consumption, cords*
1899	1,986,000	75,995,000	0.026
1910	4,094,000	91,972,000	0.044
1920	6,114,000	105,711,000	0.058
1930	7,196,000	122,775,000	0.059
1940	13,743,000	131,669,000	0.104
1950	23,627,000	150,697,000	0.157
1951	26,576,000	154,360,000	0.172
1952	26,476,000	156,981,000	0.169
1953	28,150,000	160,000,000	0.176

In the 10-year period from 1944 to 1953 pulpwood consumption rose from 16,754,000 to 28,150,000 cords—an increase of 68%.

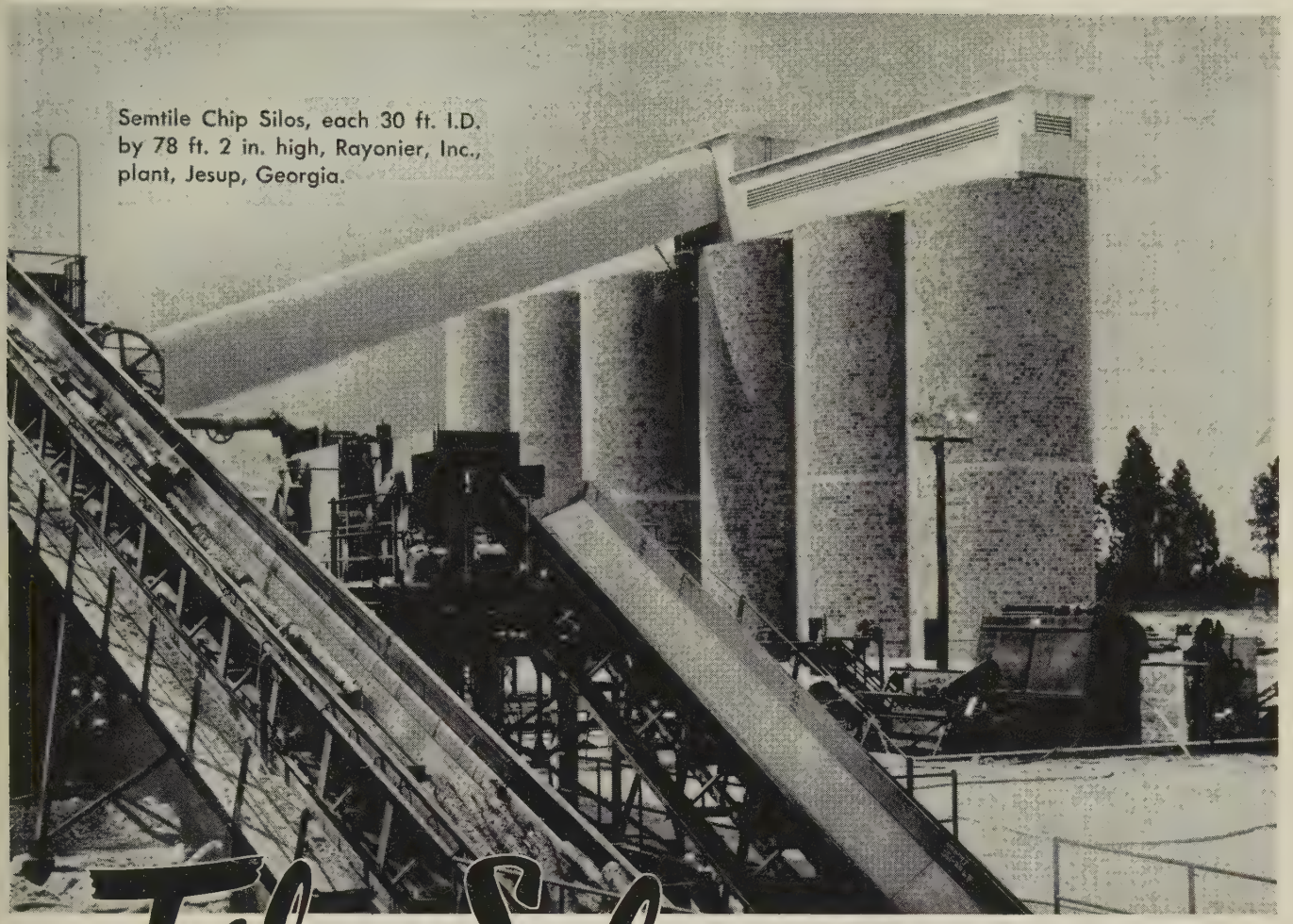

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Table IV. Pulpwood Consumption by Regions

In cords, unpeeled wood basis

Region	1941	1945	1949	1953
Northeastern	3,515,000	3,245,000	3,397,000	3,848,000
Per cent of U. S. consumption	21.2	19.2	17.0	13.6
Appalachian	1,420,000	1,444,000	1,614,000	1,822,000
Per cent of U. S. consumption	8.6	8.6	8.1	6.5
Lake States	2,398,000	2,544,000	2,461,000	3,036,000
Per cent of U. S. consumption	14.5	15.0	12.3	10.8
Southern	6,227,000	7,208,000	9,255,000	14,752,000
Per cent of U. S. consumption	37.5	42.6	46.5	52.4
Western	3,019,000	2,471,000	3,218,000	4,692,000
Per cent of U. S. consumption	18.2	14.6	16.1	16.7
Total U. S.	16,579,000	16,912,000	19,945,000	28,150,000

The consumption of pulpwood varies considerably from region to region, and the rate of increase in consumption varies. The greatest rise in consumption has been in the South.

Of the total pulpwood consumed, about 86% is softwoods. Table V shows the approximate proportions of the various species used:

Table V. Pulpwood Consumption by Species[a]

Species	Per cent of total consumed
Softwoods	
Southern pines	43
Spruce and fir	22
Hemlock	17
Other softwoods (cedar, larch, Douglas-fir, other pines)	4
Hardwoods	
Aspen, oaks, birch, gum, etc.	14

[a] Based on 1952 production of pulp.

Pulpwood accounts for about 17% of the wood harvested each year from the forests of the United States.

THE END PRODUCTS OF PULPWOOD

The physical and mechanical characteristics of the wood in the trees determined the pulp products for which the different species are best suited. Length of wood fibers, their strength and color are important. The resin content of the fibers also is a deciding factor.

The principal products obtained from the various species of pulpwood most commonly used are given below. Continuing research of the pulp and paper industry is constantly increasing the range of adaptability of each species.

Species and Principal Products Obtained

Spruce, Balsam Fir, Western and Eastern Hemlock. Bags, bristols, wrapping paper, rayon, plastics, newsprint, explosives, absorbent papers, cellophane, photographic film, tissues, printing papers, greaseproof papers, envelope papers, building and insulating papers, tag stock, fruit tissues, bond.

Southern Pines, Jackpine. Kraft paper, bag paper, container board, wrapping paper, tag stock, toweling, envelope paper, insulating paper, sheathing paper, fruit tissues, gummed tape, folding boxboard, bond, book paper, onionskin paper.

Douglas-Fir. Newsprint, book and magazine papers, absorbent papers, envelope papers, cover papers, blotting paper, bristols, container board, kraft paper, bag paper, wrapping paper.

Aspen. Book papers, coarse papers, filter paper, paperboard.

Other Hardwoods. Book and magazine papers, writing paper, absorbent papers, coarse papers.

THE PULPWOOD SUPPLY

The demand for pulpwood, to meet the needs of the American people for paper and paper products, has increased faster than that for any other forest product. From the close of World War I to the start of World War II, the consumption of pulpwood has increased 162%. Since the close of World War II there has been an additional increase of 105%. It has been estimated recently, after a careful study of the nation's pulp requirements, that pulpwood consumption in the next 20 years will increase 84% more.

Most of the pulpwood supply comes from the privately owned commercial forest lands of the United States. The amount imported has been declining each year, and this situation is not expected to change. Indications are that the forests of this country, if managed properly, will be able to meet our requirements easily.

Table VI. Commercial Forest Lands Owned and Leased by Pulp Companies, by Pulpwood Producing Regions[a]

Region	Acres owned	Acres leased	Total
Northeast	7,913,107	202,350	8,115,457
Appalachian	230,158	10,689	240,847
Lake States	1,638,812	199,541	1,838,353
South	11,507,192	1,497,185	13,004,377
West	4,504,844	119,588	4,624,432
Totals	25,794,113	2,029,353	27,823,466

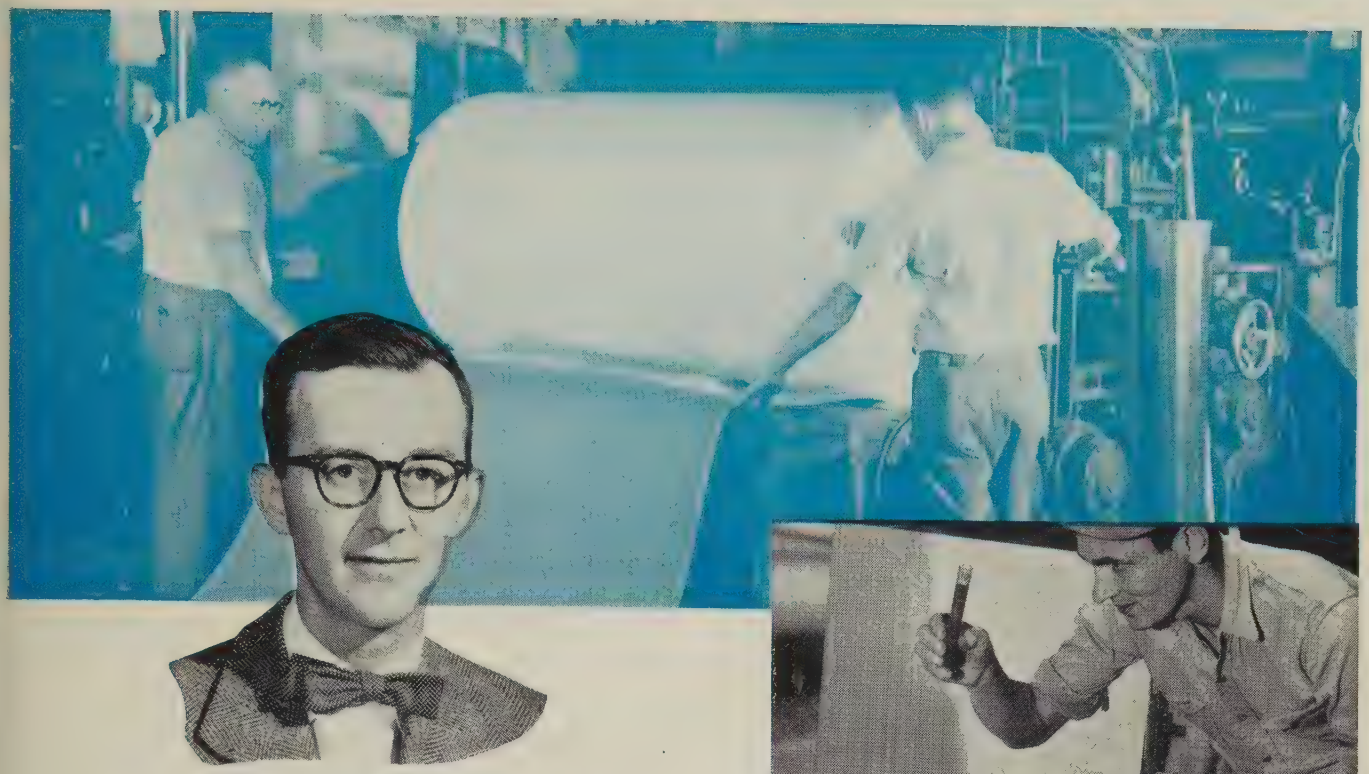
[a] In some cases the lands listed are owned by companies which produce lumber and other forest products in addition to pulpwood.

To meet the demand for pulpwood the industry is engaged in some of the most intensive and progressive programs of forestry to be found anywhere in the country. In some cases the forest lands are managed solely for the production of pulpwood. In most cases, however, pulpwood is only one of several products harvested from the forests, often as a measure to improve the rate of growth and the quality of the trees left growing for sawlogs or other commodities.

These forestry programs are aimed at obtaining maximum and continuing production of pulpwood and other forest products from the company-owned or leased lands, and providing assistance to other private landowners in the proper management and protection of their forest properties.

Pulp companies own or lease 6.1% of the nation's commercial forest lands.

The industry also owns and operates forest tree nurseries to provide planting stock where needed to



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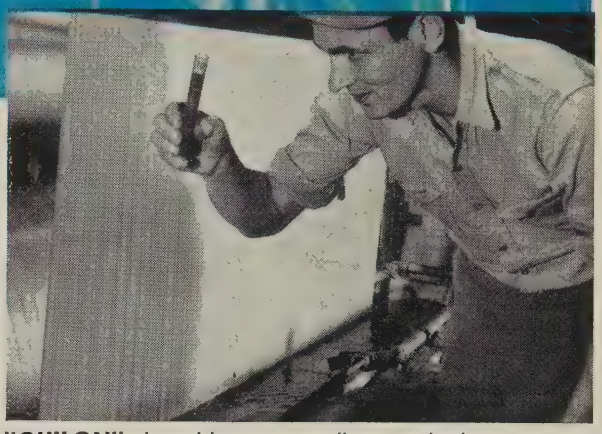
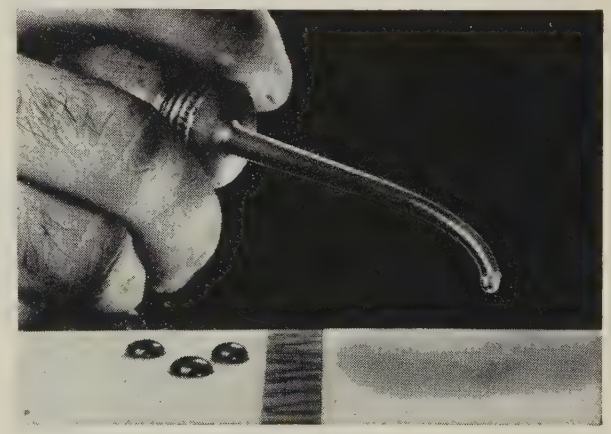


"QUILON" also adds water repellency and release properties to the high wet strength of "Patapar" vegetable parchment. Here it's being applied.



OIL-DROP TEST shows how parchment treated with "Quilon" (left) stops oil crawl . . . resists penetration and staining. Oil spreads and crawls on conventional grease-resistant parchment (right).

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establish forests of pulpwood species on their own or their neighbors' idle lands. These nurseries, numbering 26 in 1953, have a capacity of 60,750,000 seedlings a year and plans have been made to expand this production to 88,850,000.

Plantations had been established on 438,355 acres of company-owned lands by 1953, and 109,484 acres had been seeded.

To manage its lands for the continuous production of pulpwood and other forest products, the industry employs an army of technically trained foresters. The number is well over a thousand, most of whom are directly engaged in the management of company lands. Between 1945 and 1952 the number of technical foresters employed in forest management in the pulpwood industry increased 230%, and it is still growing.

Experts estimate that under the kind of management provided by these foresters the growth of pulpwood per acre on company lands will increase up to 40% by 1962.

In the past few years the industry has been spending increasing sums in the management of its lands. Since 1945, when the companies paid an estimated $4,000,000 for forest management and research work, the amount spent has increased 260%, to $14,400,000.

Most of the pulpwood comes from noncompany lands, much from farm woodlots and other small holdings, and it is expected that this will always be the case. While increasing amounts will come from company lands it is not probable that the industry will ever get all of its needs from that source. Most companies expect no more than 50, or at most 70% self-sufficiency in growing their own pulpwood. Even after their own lands are producing at capacity, which now appears to be in about 25 years, most pulp companies will still have to purchase on the open market millions of cords of pulpwood each year.

This being the case, the industry has been giving increasing attention to providing technical assistance to farmers and other small landowners who could not otherwise obtain it. More than 200 foresters, working in all of the pulpwood-producing regions, are employed by the industry to give technical assistance to others in the management of their woodlots. Over 10,000 owners with nearly 3,000,000 acres had been assisted by 1953.

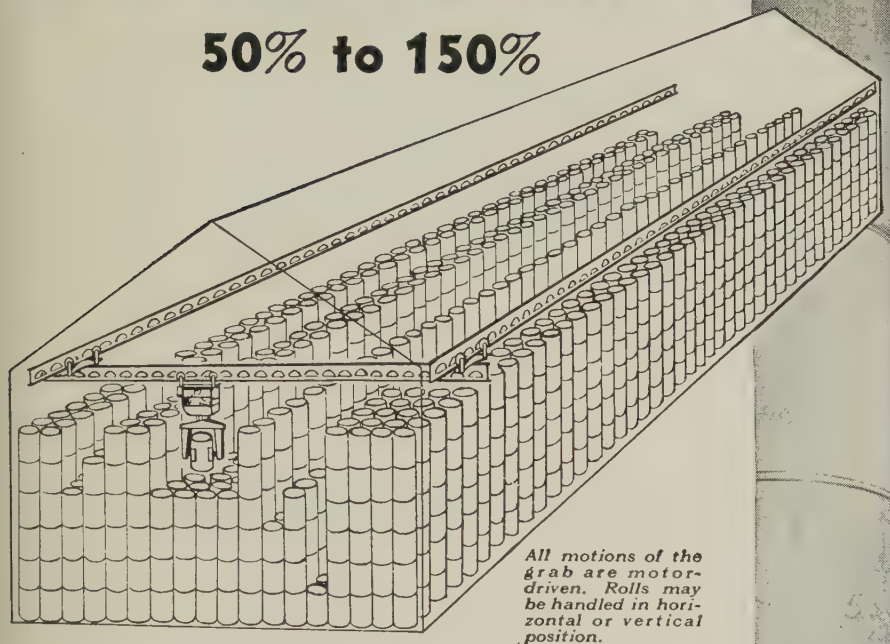
Assistance is also given in the establishment of plantations of pulpwood species. Up to 1953 the industry had distributed, free of charge, 119,867,500 tree seedlings to small landowners. This distribution is continuing at the rate of about 31,140,000 seedlings each year. To assist in planting them, companies in many sections of the country provide planting machines to the landowner free of charge or for a nominal fee.

In youth education the pulpwood industry is doing an outstanding job. Through organizations such as the Future Farmers of America, 4-H clubs, and Boy Scouts they teach the youth the fundamentals of forestry in forestry camps and schools. In some sections of the country companies hold forestry demonstrations, provide scholarships for deserving forestry students, and furnish financial assistance to colleges teaching forestry.

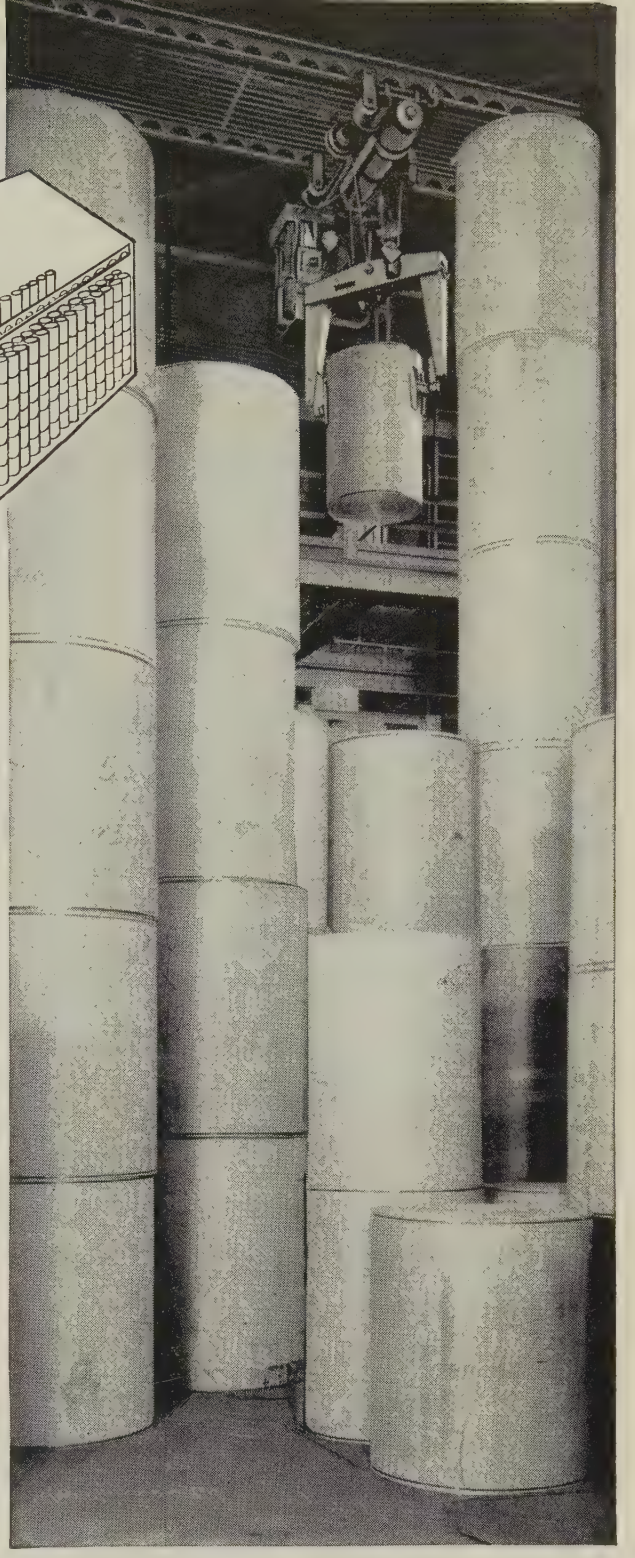
These forestry programs coupled with the increasing use of leftovers from logging and milling operations, assure this nation a good and continuing supply of pulpwood and permanence for the pulpwood industry.

INCREASE ROLL STORAGE CAPACITY

50% to 150%



All motions of the grab are motor-driven. Rolls may be handled in horizontal or vertical position.



From 50% to 150% more rolls can be stored in a building that is of sufficient height to accommodate a Cleveland Tramrail overhead crane and motor-driven roll grab, because:

1. The entire floor area is utilized.
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Rooms with many thousands of rolls can usually be served efficiently with only one man who handles all operations from the crane cab. Even where there are 50 or 100 different paper classifications, any type roll may be quickly stored or retrieved.

Reduction in paper spoilage is another of the many advantages of the Cleveland Tramrail method. In some plants this means a savings of 1% of all paper handled.

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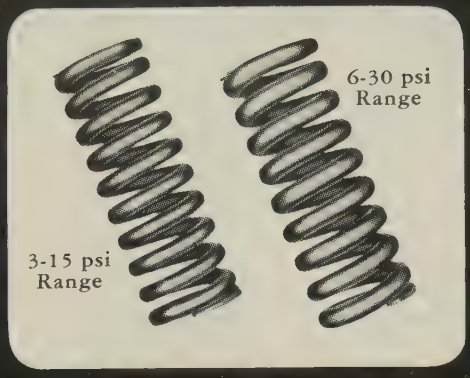
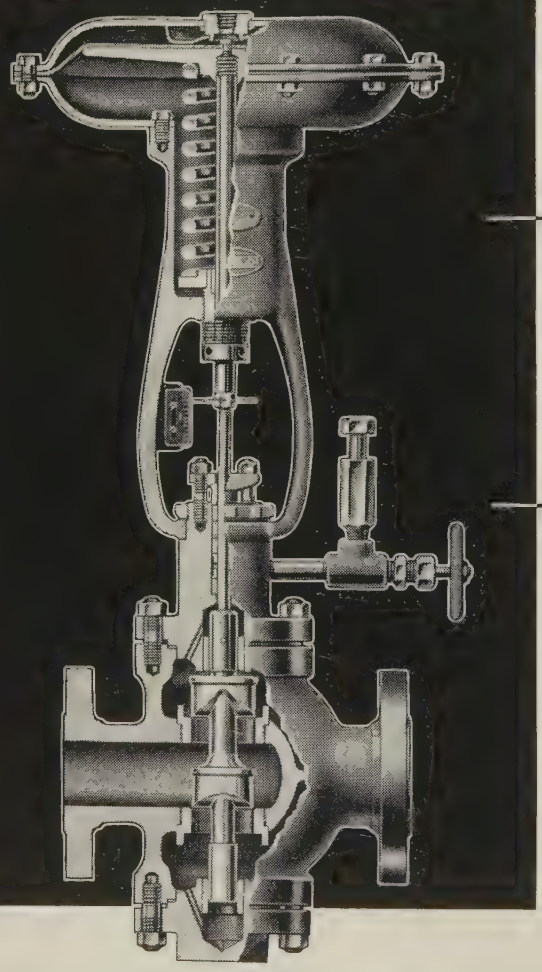
6-30 PSI
SPRING RANGE





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Makes initial spring force up to 4000 pounds available for large air-to-open single seated valves operating at high inlet pressures.

Provides large operating force at beginning of stroke.

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Compact, because diaphragm motor with, for example, 200 sq. in. effective area becomes equivalent to 3-15 psi motor with 400 sq. in. effective area.

And No Extra Cost

Both 3-15 and 6-30 psi spring ranges are "standard" — there is no extra charge for the higher range.

NOTE: There is a nominal extra for *oversized* motors which give you *even greater* power where necessary.

Operating Air is No Problem

because

Masoneilan Pneumatic Controllers are available with 6-30 psi (as well as 3-15 psi) output at *no extra cost.*

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Masoneilan Boosters (1 to 2 input-to-output ratio) may be used with 3-15 psi output instruments without positioner.

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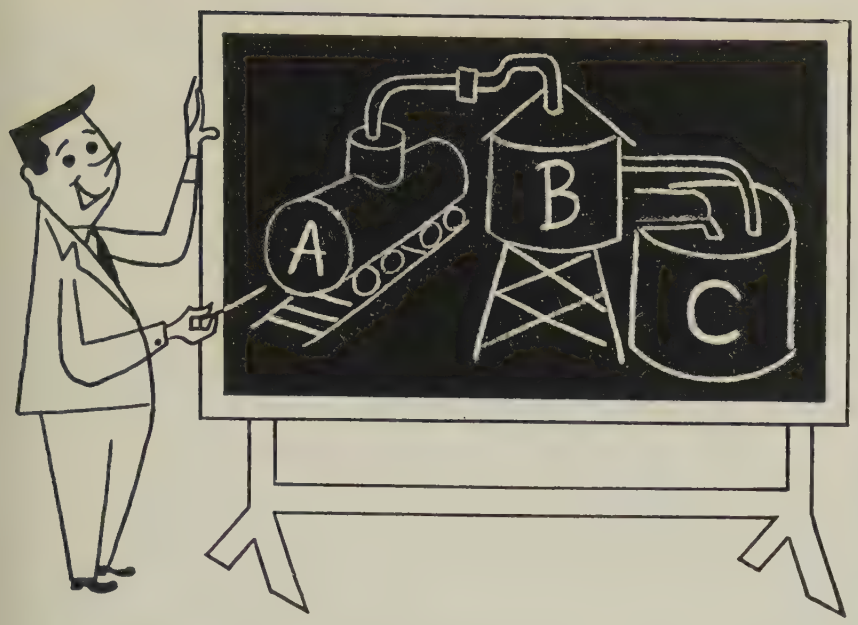

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you pay less in many areas for liquid alum, based on solids content, than you do for dry.

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rule out manual labor—your pumps and pipes do all the work—no dust, no mess, no storing or hauling problems.

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there's no guessing, no spilling, when you meter Cyanamid's Liquid Alum directly and accurately into your pulping equipment.

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CHEMICAL PROGRESS WEEK-MAY16-21

Recent Mill Developments with Cyanamid Paper Chemicals

Improved filler and fiber retention was attained by a large eastern mill by the use of Sodium Phospho Aluminate. When 1% of aluminum sulfate and 0.35% of SPA was added at the discharge bird screens, filler and fiber retention was raised from 39% to 47%.

* * *

Top specification panel board for automotive lining is being made with the following specifications: rosin size, 3% on dry weight of fiber; ALWAX* 200-A Size, 1% on dry weight of fiber. This board will not absorb more than 10% of its own weight on 24-hour water immersion. Absorptions as low as 7½% are recorded using more ALWAX 200-A.

* * *

A reduction in the viscosity of coating colors is gained by the use of small amounts of AZITE® Liquefier. Applied to both casein and alpha protein colors, an eastern mill reduced viscosities by 43% measured at slow Brookfield spindle speeds and 25% at high speeds.

* * *

Pitch dispersing effect is noted by a midwestern mill when PAREZ® 607 Resin is used instead of a urea resin. Whenever pitchy wood is run with 607 also in the furnish, the 607 evidently deposits the pitch on the fiber so no sticking occurs in the system. With urea, pitch trouble continued.

*Trade-mark

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PAPER CHEMICALS DEPARTMENT
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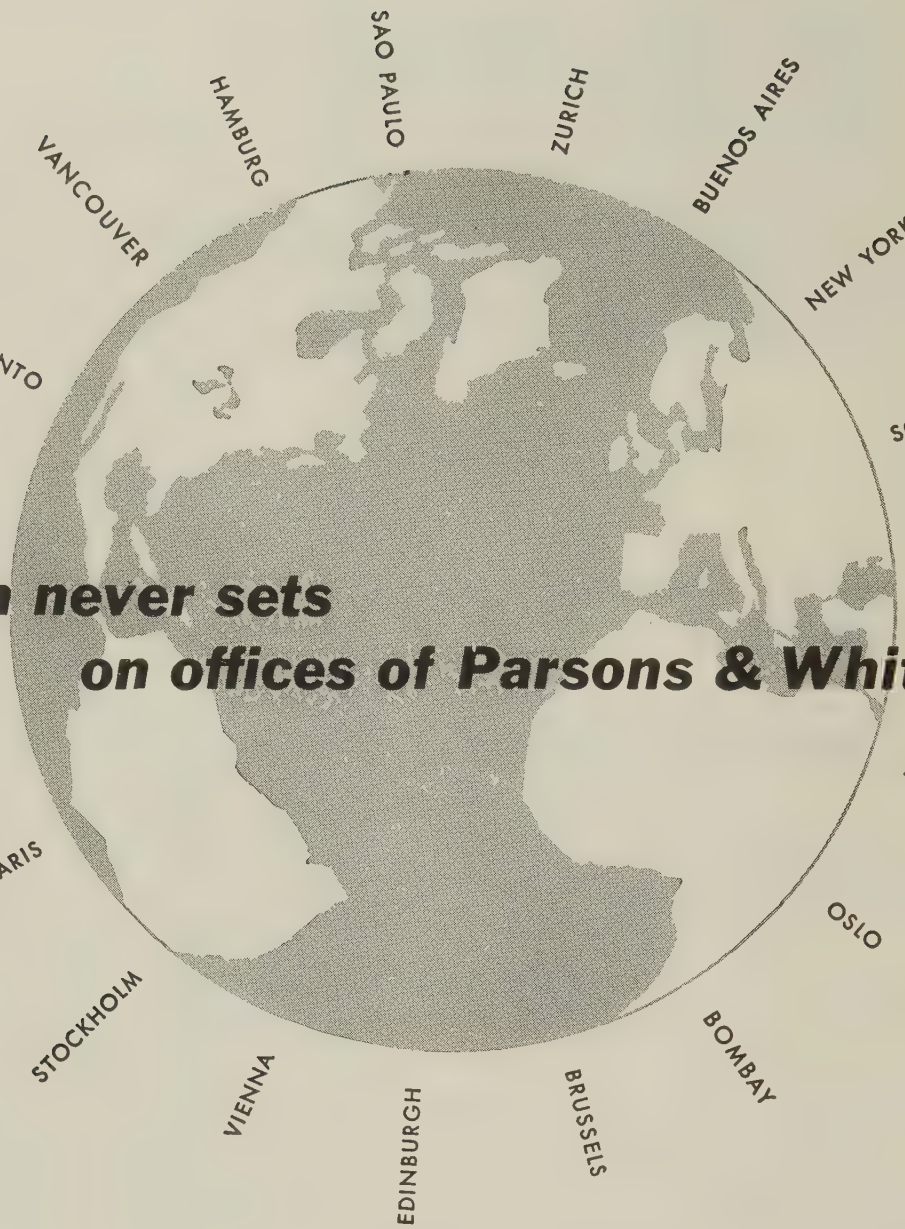
In Canada: North American Cyanamid Limited, Toronto and Montreal



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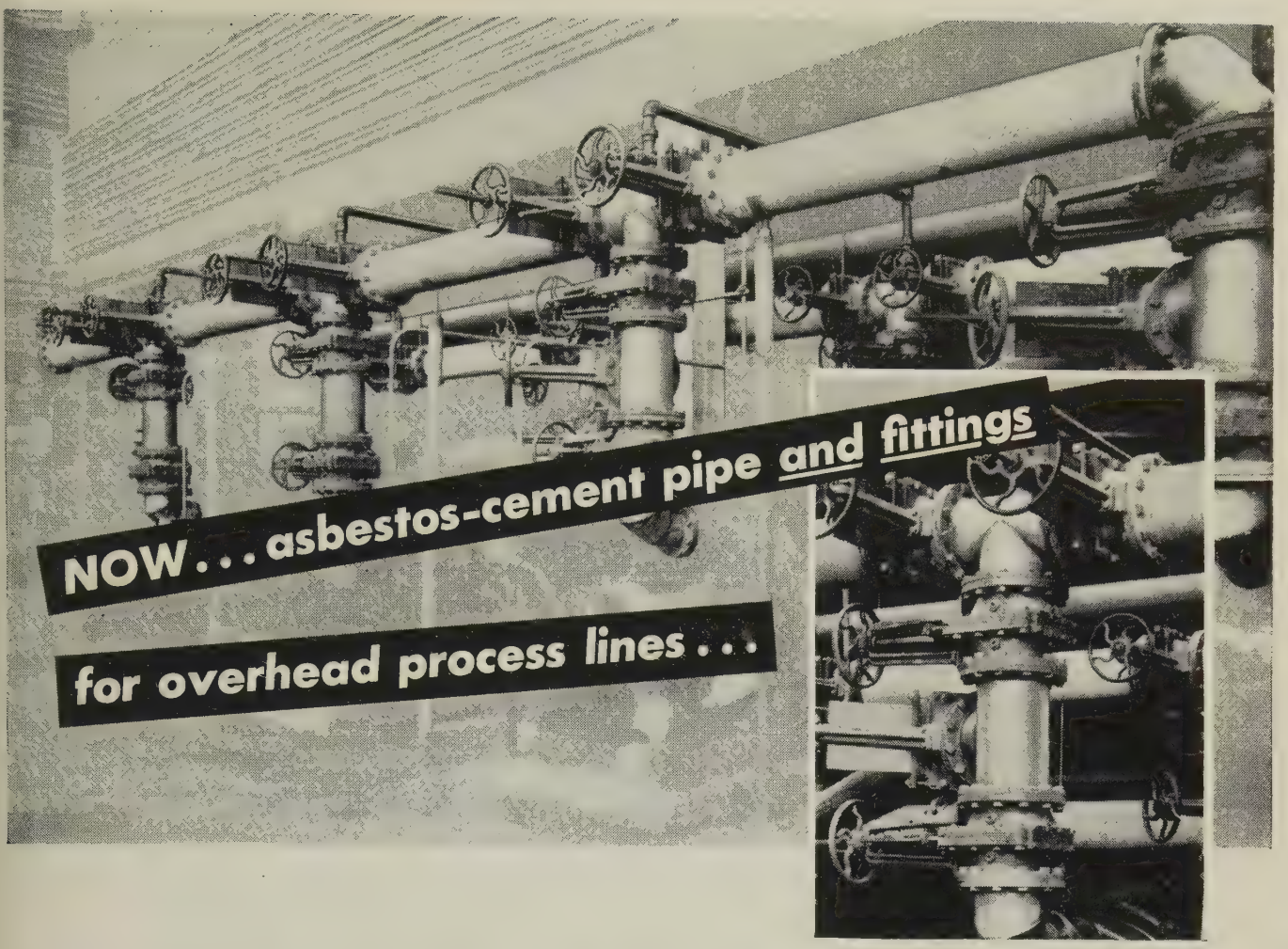
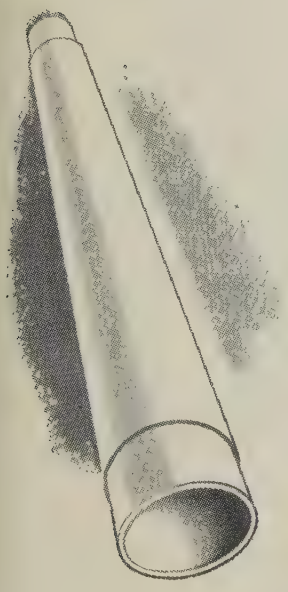


Transite Pressure Pipe provides high carrying capacity and economical, efficient service...



You can now obtain Transite* asbestos-cement Pressure Pipe with Transite-lined Streed Fittings for your overhead process systems. This permits the installation of high strength non-metallic pipe for handling raw and treated water, washed and unwashed pulps, stocks of all kinds, multi-stage bleaching systems (except direct chlorination) and certain mill wastes. There is no better way to provide clean pulp and stock than by handling it through Transite Pressure Pipe.

Low installation costs—Transite is light in weight, easy to handle, and can be drilled, cut, threaded and machined with standard tools. *And*, because its carrying capacity stays high, you can specify the smallest diameter pipe necessary . . . thus making the minimum capital investment.

Low pumping costs—Transite Pressure Pipe offers exceptionally low frictional resistance to the flow of liquids (flow coefficient C=140 for water). Since it is resistant to sliming and bacterial growths, this high carrying capacity is continuously maintained so that pumps can be operated at maximum efficiency and lowest cost.

Low maintenance costs—Transite cannot rust and is highly resistant to the corrosive action of mild acids and alkalies. Consequently, it requires a minimum of maintenance throughout its long life.

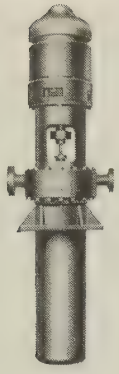
For underground service too, such as water supply or fire lines, Transite Pressure Pipe offers the same outstanding advantages. To obtain further information on Transite Pipe Systems for paper mills, write Johns-Manville, Box 60, New York 16, N. Y.

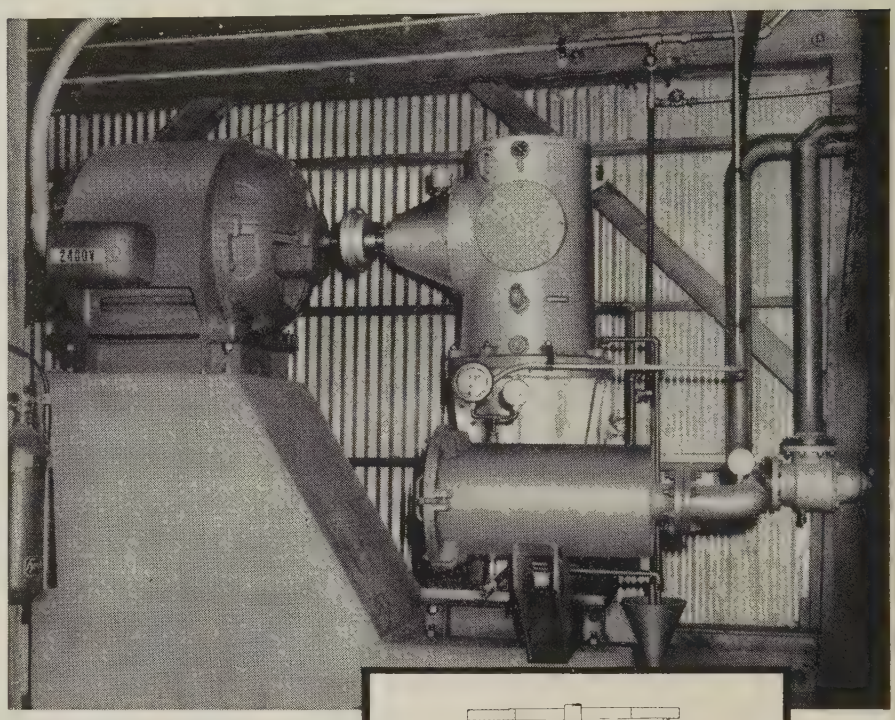
*Reg. U. S. Pat. Off.

JOHNS-MANVILLE JM PRODUCTS

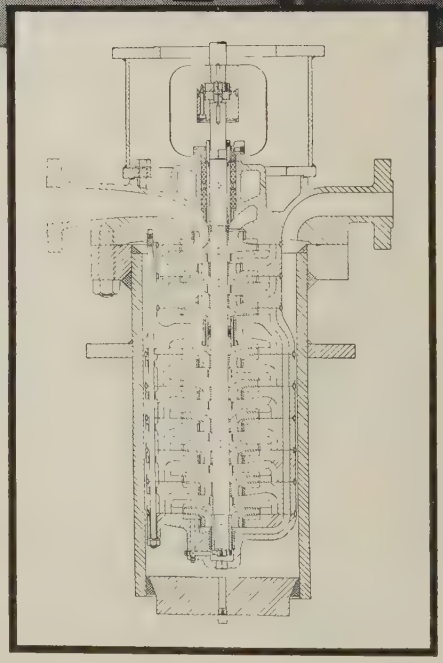
Johns-Manville TRANSITE PRESSURE PIPE

I-R multi-stage vertical pump provides 1500 lb. pressure for LOG DEBARKING at HARRIS PINE MILLS





Ingersoll-Rand 11-stage Class VHTB pump in hydraulic debarking service at Harris Pine Mills, Pendleton, Oregon. Driven by a right-angle speed-increasing gear at 4400 rpm, this unit is rated 350 gpm, 1500 psi discharge. Intake strainer is shown in lower foreground.



Cross-section of Class VHTB pump. Each stage consists of impeller, combined diffusor and channel piece, and renewable wearing ring. Since each stage is a complete pump in itself, the design is extremely flexible and readily adaptable to a wide range of operating conditions.

IN stripping the Bark from lumber mill logs the hydraulic method saves much time and effort. But it's tough service for pumps—requiring high pressure as well as dependability and freedom from costly shutdowns of the debarking operation.

At Harris Pine Mills, in Pendleton, Oregon, the Hansel Engineering Company solved the problem satisfactorily with the installation of an Ingersoll-Rand Class VHTB 11-stage centrifugal pump. This vertical-type unit delivers 350 gallons of cold water per minute at 1500 lb. It is motor driven through a right-angle step-up gear which gives the pump an operating speed of 4400 rpm.

In the VHTB pump, there is no radial load on the shaft; and hydraulic axial thrust is reduced to a minimum by the opposed arrangement of the impellers. Piping connections are straight through and in-line, and there is only one stuffing box. These factors contribute to exceptional dependability as well as ease of installation and servicing. Ask for I-R pump specialist for complete details, or write for Bulletin No. 7096.

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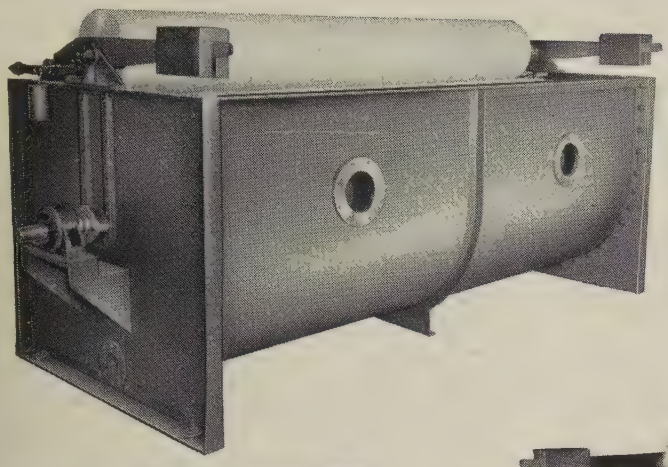
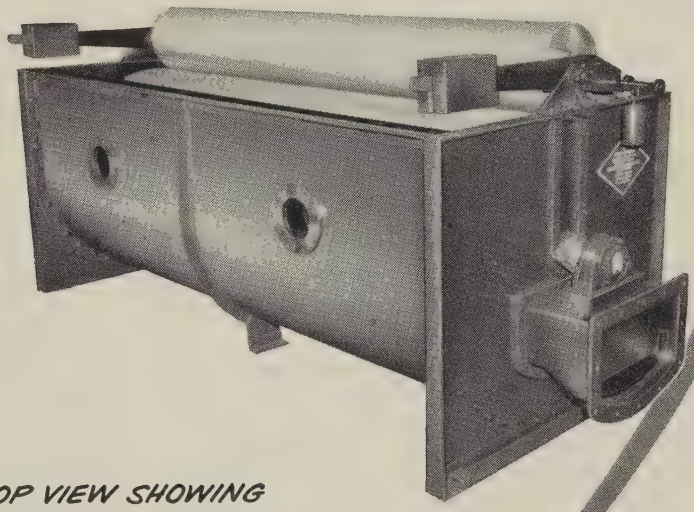


VIEW OF END AND INTAKE SIDE OF COWAN DECKER

VIEW OF EFFLUENT DISCHARGE END FROM INTAKE SIDE



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35 tons/day — Groundwood
85 tons/day — Sulphite
100 tons/day — Kraft

APPLETON MACHINE COMPANY
APPLETON WISCONSIN

Exclusive U.S. licensee for Cowan Deckers

Special Research Facilities at the Lowell Technological Institute

JOHN LEWIS

In October of 1947 Dean Simon Williams of the Lowell Textile Institute wrote to a large number of Massachusetts paper and leather companies. In those letters he stated that a decision had been made to investigate the practicability of establishing paper and leather engineering departments in addition to the long-established textile courses.

PROGRESS OF THE DEPARTMENT OF PAPER ENGINEERING OVER ITS FIRST 5 YEARS

An encouraging majority of replies indicated that there was a demand for graduates from such schools. Therefore, a further decision was made by President Kenneth Fox and the Board of Trustees to petition the Legislature of the Commonwealth of Massachusetts to grant funds for housing these departments in a "paper and leather building." This was accomplished and the building was started in 1950 with facilities for leather on the first floor, paper on the second floor, and general classrooms, laboratories, and offices on the third and fourth floors (Figs. 1 and 2). This building which was completed and equipped at a cost of about $750,000 was first occupied in March of 1952. Up to that time classes were held in the existing facilities of the Institute.

The paper engineering curriculum became official in September of 1949 with the appointment of the late Geoffrey R. Broughton as professor and head of the department. Upon his able shoulders was placed the burden of establishing a sound curriculum, planning the details of the paper section of the building, attracting the first students, and establishing the ever-important contact with the industry the department serves.

The author wants to take this opportunity to publicly acknowledge the great job that "Geoff" did in that job. We will all miss his contributions to the paper industry.

Since its start in 1949 with Mr. Broughton, the staff of the department has grown to its present complement of three. Alfred K. Hobbs became the first instructor under Mr. Broughton in September of 1950. He is presently in the armed services and expects to return next September. In his absence, we have been very fortunate to have the benefit of the experience and ability of Horace N. Lee. In October of 1953 we were pleased to welcome Norwood H. Keeney to our staff in the newly created appointment of assistant professor. It was the author's privilege to succeed Mr. Broughton as professor and head of the department when he left to take the chairmanship of the Department of Chemical Engineering at the University of Rochester in September, 1952.

The Curriculum

An early decision was made to establish chemical engineering as the engineering basis of the curriculum. President Martin J. Lydon, Dean Charles F. Edlund, and the author who have replaced the original founders of the course have seen no reason to change this decision. We are proud that two of our graduates have gone directly on to M.S. graduate work in chemical engineering. They expect to complete their study in about the same time it takes for a B.S. graduate from a "conventional" chemical engineering curriculum.

In our papermaking courses we are definitely following the pattern of emphasis already established for us by the paper industry of the Commonwealth of Massachusetts which, as you know, is chiefly paper and board making and conversion.

It is not our objective to make expert technicians of our graduates. Rather, we attempt to teach the elements of sound application of the scientific method to solving of problems. We then try to encourage original thinking—to produce men that can "engineer" a better piece of paper or board or suggest a better method. When our men leave us, they have acquired the proper seasoning of the salt of the technical and the pepper of the practical. The author uses the latter phrase which was coined, he believes, by our friend Fred Soderberg, because he has always remembered it and believed it should be applied in the educator's job of preparing young men for industry.

John Lewis, Professor and Head, Paper Engineering Department, Lowell Technological Institute, Lowell, Mass.

Table I. Annual Enrollment of Students

	1950–1951	1951–1952	1952–1953	1953–1954	1954–1955
Seniors	0	1	1	9	6
Juniors	1	1	10	7	9
Sophomores	1	11	8	13	17
Freshmen	10	12	14	25	39
Graduate	1	1	0	0	0
Total	13	26	33	54	71

Growth of Enrollment

Table I shows the growth of enrollment over the first full 5 years of the existence of the department. By and large this student body has come from the Lowell-Lawrence area. However, the trend to students from more distant areas is now well established. Dalton, Mass.; Pawtucket, R. I.; and Jersey City, N. J.; among several other distant points, are now represented.

Location of Graduates

Geographically, our graduates are already widely spread. Table II lists the companies where they are now employed, or were employed, until military service intervened.

Professor James Bell, the placement director, and the author work closely together. They, of course, welcome inquiries from the industry at large concerning the availability of the graduating seniors. They prefer the system of company interviews on campus but other arrangements can be made.

Graduate School

Graduate study is offered in the department for the M.S. Degree in Paper Engineering. This program has not been particularly active because of the attention we have had to give to the building of the undergraduate program. Now that we have adequate staff time we plan to focus much more attention on this important phase of our program.

In the fall of 1955 we want at least five or six graduate students. We will welcome B.S. graduates from other paper schools as well as our own and we hope to attract chemists and engineers from schools with nonspecialized curricula who wish special training and research experience in the fields of paper and board making and converting. It is our intention to keep the program of study flexible, according to the desires of the students.

We are actively seeking graduate fellowships to provide assistance in attracting able students to the industry by way of our graduate program. It is commonly agreed, that in this day and age, with the job placement as favorable as it is at

Table II. Location of Graduates

Company	*City*
Great Northern Paper Co.	Millinocket, Me.
University of New Hampshire	Durham, N. H.
Dixie Cup Co.	Easton, Pa.
Fraser Papers, Ltd.	Madawaska, Me.
International Paper Co.	North Tonawanda, N. Y.
McLaurin-Jones Co.	Brookfield, Mass.
Crane Co.	Dalton, Mass.
University of Maine	Orono, Me.
Sealright Corp.	Fulton, N. Y.

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For TOPS in Kraft Pulp Quality!

Chlorine Dioxide Bleaching WITHOUT HYPOCHLORITE!

- Better Strength
- Higher Brightness
- Cleaner Pulp

Solvay is proud to announce the successful production of kraft pulp that sets a new standard in quality through the use of chlorine dioxide, *without hypochlorite.*

If you are interested in developing a cleaner kraft pulp with better strength and a new high in brightness, please write us and we will supply you with details. There will be no cost or obligation.

For Plants With Waste Disposal Problems!

High Brightness Pulp WITHOUT CAUSTIC EXTRACTION!

Mills producing kraft, soda or sulphite pulp for paper-making purposes with stream pollution or similar waste disposal problems can now bleach with chlorine dioxide in three stages—*without a caustic extraction intermediate* and get an 85 G.E. Brightness at a practical cost. This new system has been thoroughly tested and is successfully operating on a production basis.

If you would like further information about this three-stage bleaching operation, write us for full details without cost or obligation.

These two new Solvay advances in chlorine dioxide bleaching were placed in operation with the assistance of the special Paper Section of Solvay's Technical Service. Information regarding either or both of them will be supplied without charge. Simply write us giving details of your current operation. All information will be in strictest confidence.

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Soda Ash • Caustic Potash • Ammonium Bicarbonate
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Methylene Chloride • Calcium Chloride • Caustic Soda
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Fig. 1. Paper and Leather Engineering Building

the B.S. level, graduate schools especially need this help from industry.

Evening and Summer Courses

Evening courses have been offered each year since the first year of existence of the department to local people who are seeking a general knowledge of papermaking and converting.

Table III. Industrial Advisory Committees

Advisory Committee

Courtney H. Reeves, *Chairman*, Carter-Rice Co., Boston, Mass.
Wm. Bond Wheelwright, *Secretary*, Callaway Associates, Boston, Mass.
Norman I. Bearse, Champion-International Co., Lawrence, Mass.
James R. Carter II, Nashua Corp., Nashua, N. H.
Amor Hollingsworth, Jr., Tileston and Hollingsworth Co., Boston, Mass.
Frederic S. Klein, Byron Weston Co., Dalton, Mass.
James A. LeRoy, McLaurin-Jones Co., Brookfield, Mass.

Equipment Committee

Amor Hollingsworth, Jr., *Chairman*
Gustaf Peterson, *Vice-Chairman*, Rice-Barton Research Corp., Worcester, Mass.
Roy Bolton, John W. Bolton and Sons, Inc., Lawrence, Mass.
Malcolm B. Hall, Foxboro Co., Foxboro, Mass.
Alexander O. Jenkins, Bird Machine Co., East Walpole, Mass.
Robert F. Vokes, Dilts Machine Works Div. of Black-Clawson Co., Fulton, N. Y.

Guest Lecturer Program Committee

James R. Carter II, *Chairman for Converting*
Frederic S. Klein, *Chairman for Papermaking*

Publicity and Library Committee

Wm. Bond Wheelwright, *Chairman*
Joseph V. Kopycinski, Lowell Technological Institute, Lowell, Mass.

Practical Workers in Industry

Norman I. Bearse, *Chairman*
Chester H. Child, Merrimac Paper Co., Lawrence, Mass.
Randall H. Doughty, Fitchburg Paper Co., Fitchburg, Mass.
Percival Gooding, Strathmore Paper Co., West Springfield, Mass.
John R. Lunt, Robert Gair Co., Haverhill, Mass.
Lloyd M. Perry, Nashua Corp., Nashua, N. H.

Research Committee

James A. LeRoy, *Chairman*
Gardner R. Alden, Dennison Manufacturing Co., Framingham, Mass.
A. M. Altieri, Tileston and Hollingsworth Co., Hyde Park, Mass.
R. F. Bailey, E. I. du Pont de Nemours & Co., Inc., Providence, R. I.
Bigelow Crocker, Crocker-Burbank Co., Fitchburg, Mass.
Wilmer F. Kallock, Marvellum Co., Holyoke, Mass.
Frederic S. Klein, Byron Weston Co., Dalton, Mass.
Francis F. Newkirk, American Sisalkraft Corp., Attleboro, Mass.
Harold L. Peckham, Oxford Paper Co., New York, N. Y.
Herman W. Verseput, Robert Gair Co., Uncasville, Conn.

Representatives from sales organizations, printing plants, manufacturers, and converters, to name a few, have attended the classes in "Pulp and Paper Manufacture," "Paper and Board Converting," and "Paper Testing Laboratory." There have been about 25 in attendance each year.

In the summer of 1950 and again in 1951, Mr. Broughton conducted intensive 2-week Summer courses in "Paper, Its Properties and Uses." Representatives were in attendance from a wide geographical area and from a variety of organizations. Last summer we announced the renewal of the program and we are planning the same program again from June 20 to July 1, inclusive, this year.

Industrial Advisory Committees

The officials of Lowell Tech have always been most appreciative of the assistance the paper industry has given to the growth of the Paper Engineering Department. That help has been invaluable from the first answers to former Dean Simon Williams' inquiries in 1947 until now.

The author wants to take the time here to publicly recognize the members of our industrial advisory committees who have given so generously of time and money. Secondly, he would like to take the same opportunity to recognize those companies which are scholarship contributors and which have provided guest lecturers.

Table III gives a list of the personnel of the various committees. Table IV is a list of scholarship donors to the Paper Engineering Department.

Table V is a list of the guest lecturers who spoke in our senior converting course a year ago. Because of our small

Table IV. Scholarship Donors

1. McLaurin-Jones Scholarship—McLaurin-Jones Co., Brookfield, Mass.
2. Boston Paper Trade Association Scholarship—Boston Paper Trade Association, Boston, Mass.
3. New England Paper Merchants' Association Scholarship—New England Paper Merchants' Association, Boston, Mass.
4. Geoffrey Broughton Paper Engineering Scholarship—
   American Writing Paper Co., Holyoke, Mass.
   Byron Weston Co., Dalton, Mass.
   Carter-Rice Co., Boston, Mass.
   Champion-International Co., Lawrence, Mass.
   Chemical Paper Co., Holyoke, Mass.
   Crocker-Burbank Co., Fitchburg, Mass.
   Fitchburg Paper Co., Fitchburg, Mass.
   McLaurin-Jones Co., Brookfield, Mass.
   Nashua Corp., Nashua, N. H.
   Robert Gair Co., New York, N. Y.
   Strathmore Paper Co., West Springfield, Mass.
   Tileston and Hollingsworth Co., Boston, Mass.

senior group this lecture course was not held last fall but we are now in the midst of a guest lecturer program in "Papermaking" for our Juniors.

SPECIAL RESEARCH FACILITIES AT THE LOWELL TECHNOLOGICAL INSTITUTE

We believe that we are in a very unique position at the Lowell Technological Institute to assist this industry in its research problems. We have the combined fiber experience of the long-established textile school and we have the later-

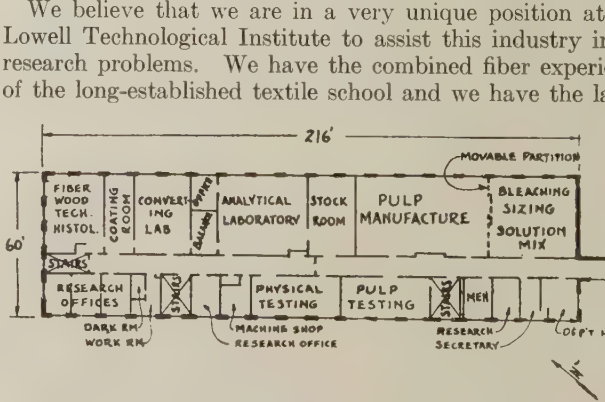


Fig. 2. Floor plan—Paper Engineering Department

PICK THE RIGHT WAX FOR PAPER PRODUCTS

Atlantic builds waxes which add trouble-free sales appeal to any product. Those recommended for paper goods assure you of a hard, glossy, scuff-resistant surface with lasting protection against blocking.

Blocking (or sticking together) occurs most often when a wax loses its hardness. Tough, hard, high-melting Atlantic 1115 Wax gives your products good blocking resistance in hot summer temperatures. Atlantic 1115 Wax is also highly resistant to the deteriorating effect of vegetable oils, so that containers stay firm and leak-proof for long periods of time.

Atlantic makes a superior wax for every use. Selecting the right wax is quick and easy when you call in your Atlantic man. He's an experienced consultant . . . knows which waxes to recommend for hardness, flexibility or a combination of these and other characteristics.

He'll arrange deliveries to suit your needs . . . in cartons or pallets, in bulk haulers or in tank cars. For full information write your nearest Atlantic office. The Atlantic Refining Company, Dept. T-5, 260 South Broad Street, Philadelphia 1, Pa.

PROVIDENCE, R. I.
430 Hospital Trust Bldg.

SYRACUSE, N. Y.
Salina and Genesee Sts.

READING, PA.
First and Penn Aves.

PITTSBURGH, PA.
Chamber of Commerce Bldg.

CHARLOTTE, N. C.
1112 South Boulevard

ATLANTIC

LUBRICANTS • WAXES
PROCESS PRODUCTS

THERE'S AN ATLANTIC WAX FOR EVERY USE

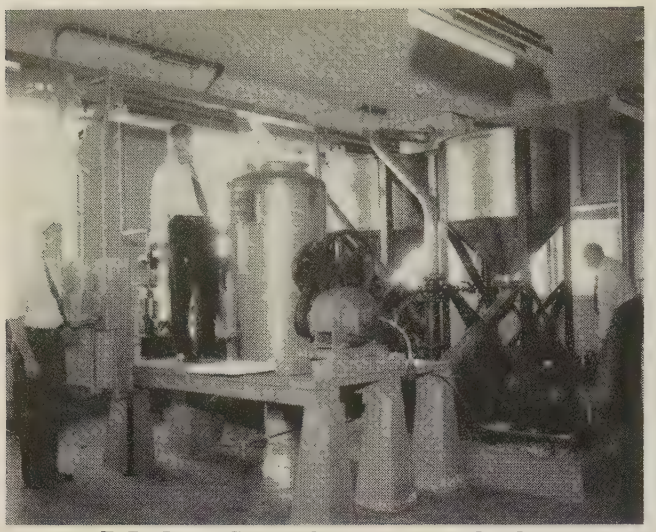


Fig. 3. E. D. Jones Co. stock preparation-deinking system

established experience of the leather, plastic, and paper departments. All of this experience may be brought together to solve paper problems through the medium of the Lowell Technological Institute Research Foundation.

Incidentally, Harold K. Knudson, Hollingsworth and Vose Co., of East Walpole, Mass., is a member of the Board of Directors of the Foundation as a representative of the paper industry.

The Research Foundation

In recognition of these unique research opportunities, the Massachusetts State Legislature has authorized the establishment of the Lowell Technological Institute Research Foundation to coordinate and administer all sponsored research at the Institute. The Foundation provides the necessary mechanism whereby programs of testing, development, and research can be initiated for specific sponsors through one central agency.

The staff includes the permanent personnel of the Foundation and the faculty members of the Institute. They use the facilities of the Institute as well as the laboratories which the Foundation has equipped with specialized facilities not generally utilized in the Institute's educational program.

Representatives of industrial and government organizations are invited to submit inquiries to the Executive Director of the Foundation regarding the feasibility of establishing programs of testing, development, or research. A conference between the representatives of the potential sponsor and the members of the Foundation staff is then held to delineate the scope of activities and to ascertain the availability of equipment, personnel, and specialized knowledge.

If the contemplated program of investigation is within the capabilities of the Foundation, a technical and fiscal proposal

Fig. 4. Microscopy and analytical laboratory

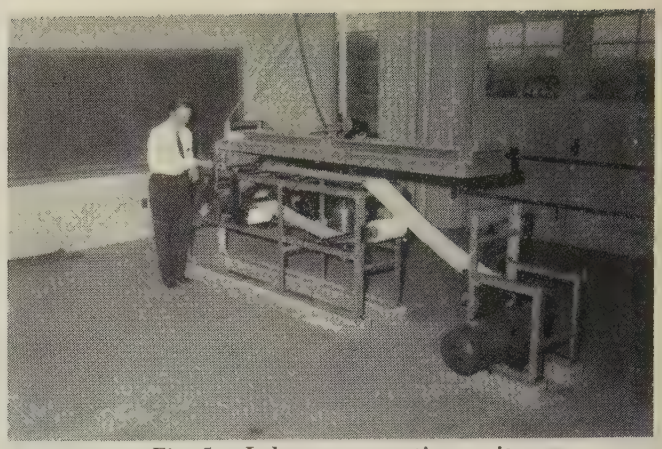


Fig. 5. Laboratory coating unit

is prepared by the staff of the Foundation and submitted to the potential sponsor for approval. Once this proposal is approved by both parties, the program is defined in a letter of agreement in the case of short term projects, or by means of a formal contract for long term projects.

A project engineer is then assigned responsibility for the direct supervision of the project. When needed, he can assign other members of the staff to participate in the program, either as direct participants or consultants. In this manner, a broad range of experience is available to the sponsor, each specialist contributing his services as required.

A close liaison is continuously maintained between the project engineer and the sponsor's representatives to insure that the emphasis is always to the best interests of the sponsor.

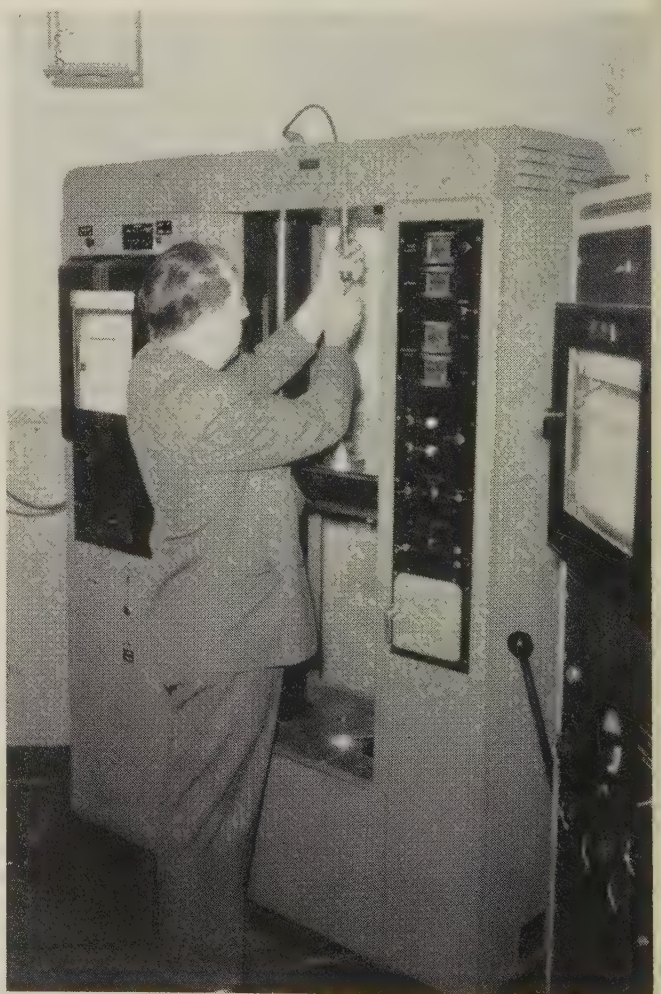


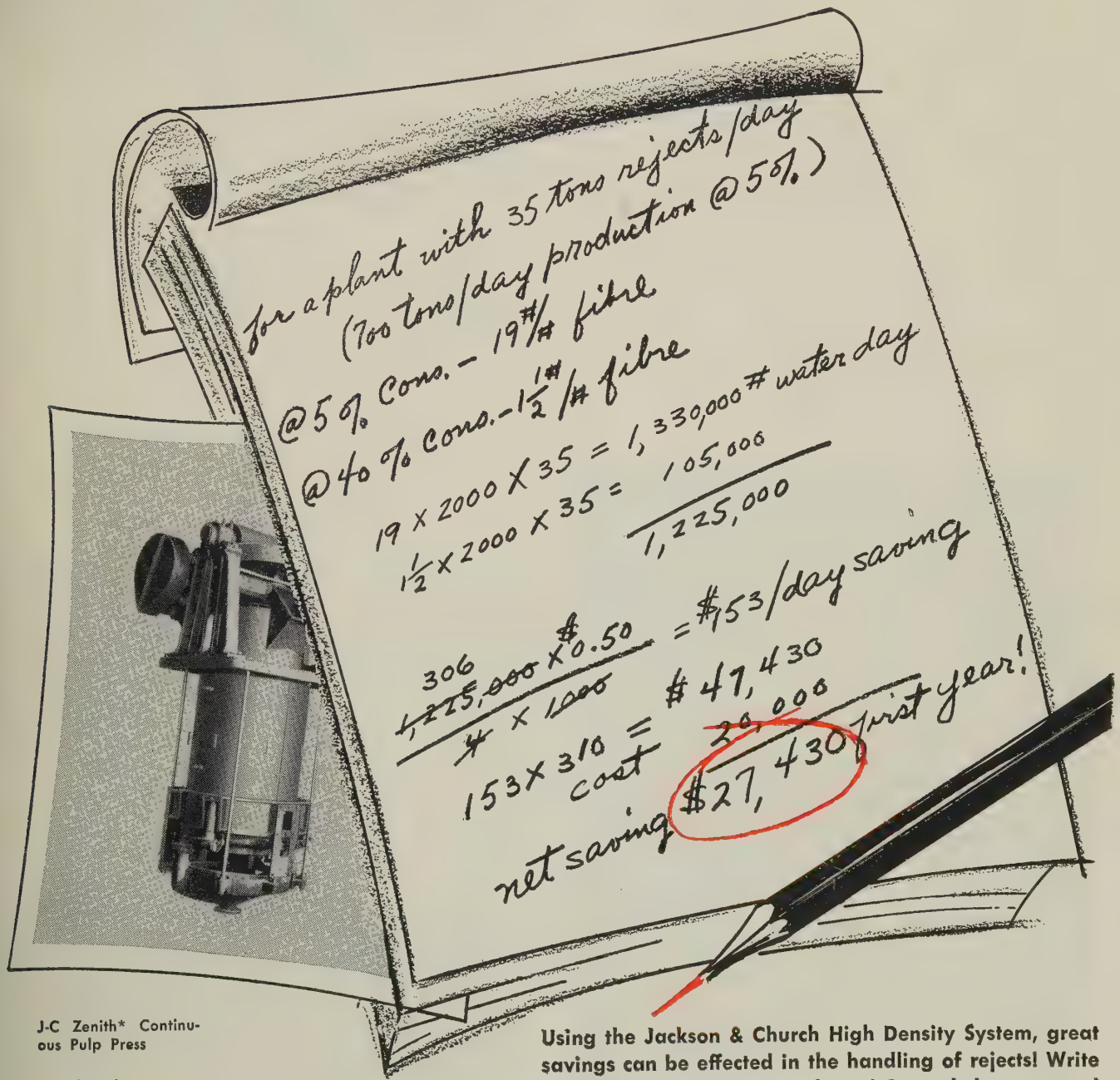
Fig. 6. Instron unit

EVAPORATORS OVERLOADED?

SHORT OF STEAM?

Rejects put back into the system at low consistency can be the cause of the trouble!

Many plants are now solving this problem simply and efficiently by using a Jackson & Church High Density System. Here is what this can mean to you in dollars-and-cents savings . . .


for a plant with 35 tons rejects/day
(700 tons/day production @ 5%)
@ 5% Cons. - 19#/# fibre
@ 40% Cons. - 1½#/# fibre
19 × 2000 × 35 = 1,330,000 # water day
1½ × 2000 × 35 = 105,000
1,225,000
306
1,225,000 × $0.50 / # × 1000 = $153/day saving
153 × 310 = $47,430
cost 20,000
net saving $27,430 first year!

J-C Zenith* Continuous Pulp Press

* Trademark

Using the Jackson & Church High Density System, great savings can be effected in the handling of rejects! Write for further information on how J-C can help you save!

JACKSON & CHURCH CO. SAGINAW, MICHIGAN

Work well done since eighty-one

Table V. Guest Lecturers—Converting

Philip S. Bolton, Robert Gair Co., Uncasville, Conn.
David C. Whitehouse, Container Corp., Boston, Mass.
George P. Mueller, Marathon Corp., Menasha, Wis.
James A. LeRoy, McLaurin-Jones Co., Brookfield, Mass.
Malcolm J. Odell, Angier Corp., Framingham, Mass.
R. M. Chamberlin, Reynolds Metals Co., Louisville, Ky.
Joseph W. Coffman, Technifax Corp., Holyoke, Mass.
Charles W. Stillwell, Dennison Mfg. Co., Framingham, Mass.
Morton A. Slavin, Erving Paper Mills, Erving, Mass.
Walter Holzberger, Champion Paper and Fiber Co., Hamilton, Ohio
Cecil Dawson, Dixie Cup Co., Easton, Pa.
Garrison Householder, Plastic Coating Corp., Holyoke, Mass.
Shy Rosen, Milprint Inc., New York, N. Y.
Richard O. Page, Courier-Citizen Co., Lowell, Mass.

Paper Engineering Department

We intend to carry out our research in the same fields in which we are specializing our curriculum. Accordingly, we have only recently completed the purchase and installation of the deinking-stock preparation system shown in Fig. 3. We have a new Oliver horizontal filter which is not completely installed but which should later prove to be a most useful tool for deinked stock washing and other types of filtration or washing studies.

In Fig. 4, Horace Lee is shown working with a group of our Junior students. As many of you know, he is interested primarily in microscopy and papermaking research. When Mr. Hobbs returns he will work primarily in this field.

The small laboratory coating unit shown in Fig. 5 is only the start of much more converting equipment which we expect to add for Professor Norwood Keeney to have available for his chosen field of paper and board converting.

Fig. 7. X-ray diffraction unit

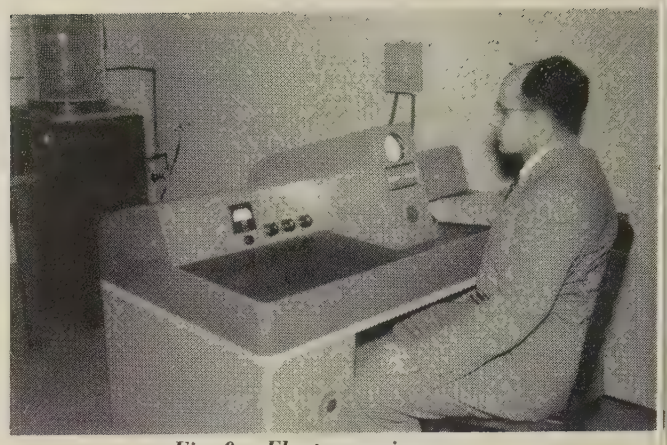


Fig. 8. Electron microscope

Leather Engineering Department

There is no other academic institution which can offer the knowledge of animal hide fiber as can Albert E. Chouinard and his staff. This is the only school in the United States offering engineering instruction leading to a B.S. Degree in leather manufacture.

One member of the staff was once directly connected with the paper and board industry. G. Arthur Brown, formerly associated with the School of Leather Tanning at Pratt Institute in Brooklyn, N. Y., has had several years experience in leather and fiberboard manufacture with Bennett Ltd. at Chambly Canton, Que.

Textile Manufacturing Division

At this meeting 1 year ago, James Wang and Mr. Broughton presented a paper dealing with making twisting-paper yarn. This covered work done on cotton twisters in the Cotton Department under Mr. Broughton several years ago when Mr. Wang was a textile graduate student. That work indicated just one of the many pieces of textile manufacturing equipment which can be used in solving industrial paper problems. It is safe to say that nearly every piece of textile manufacturing equipment found in a mill may be found in actual commercial size at Lowell Tech.

In the textile testing section there are several instruments which are not available in the well-equipped laboratories of the Paper Engineering Department. Most noteworthy of these is the Instron unit shown in Fig. 6. Professor J. K. Frederick who is shown in that photograph has a wealth of textile testing experience which can be drawn on for applicable paper problems.

Textile Engineering Department

The textile engineering department has several staff mem-

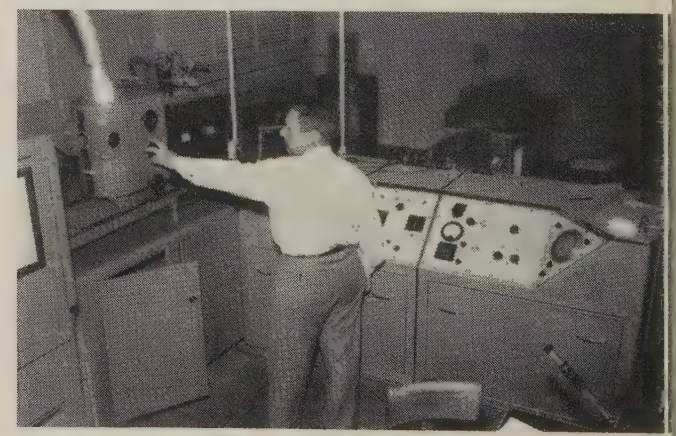


Fig. 9. Spectrograph

TEST-PROVE *for yourself how*

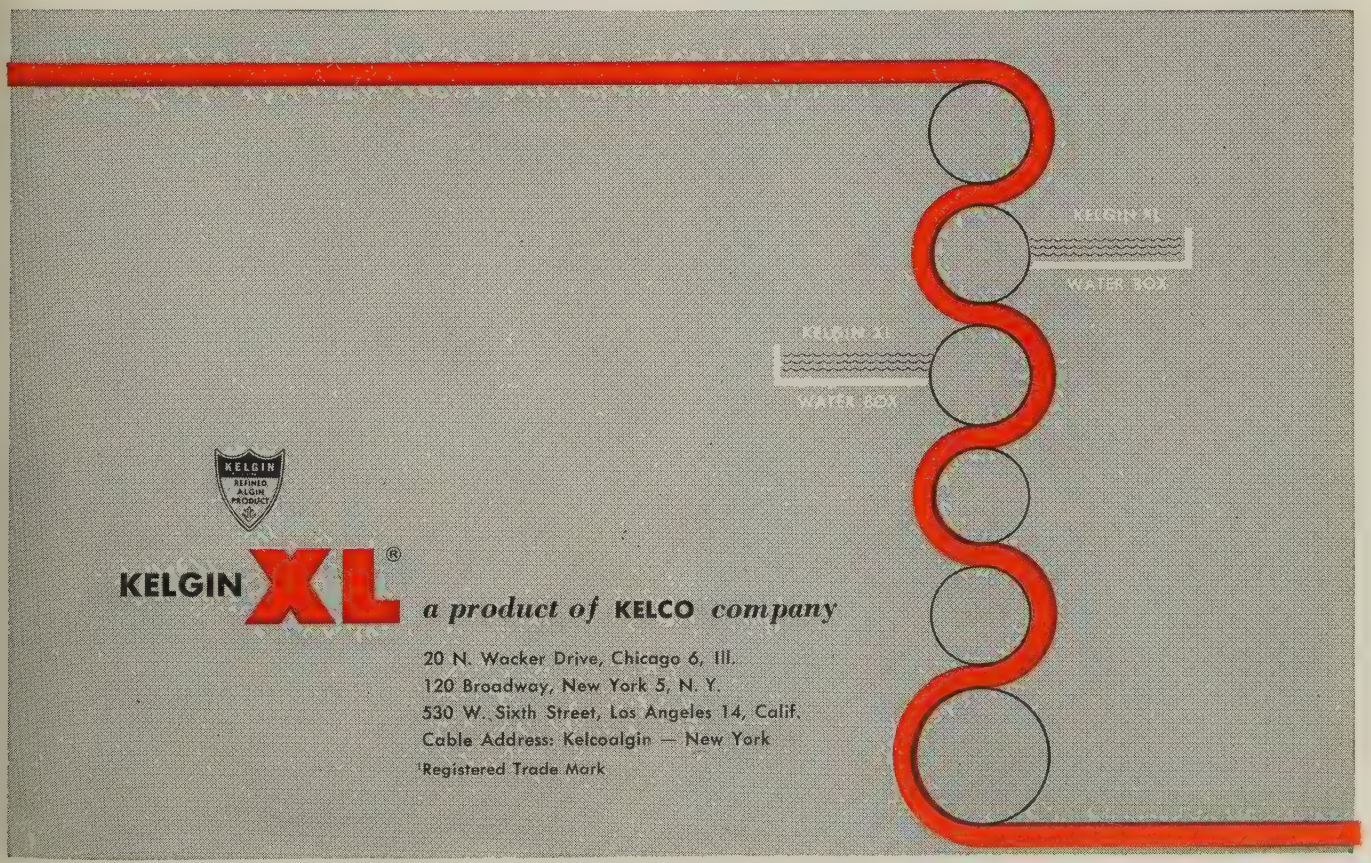
KELGIN XL

reduces calender wrapping!

You keep 'em rolling with KELGIN XL, the non-tacky surface size which virtually eliminates calender wrapping. The excellent filming properties of KELGIN XL produce improved smoothness and more uniform printing surface. Oil and varnish resistance are increased without adverse effect on other paper qualities.

Ordinarily applied from calender water boxes or size tubs as 1% to 3.5% solution, with concentration used depending upon type and degree of finish desired.

Write your nearest regional office for complete information now.



bers who have evidenced interest in some of the problems of papermaking. To pick out just three of the many specialties they have developed over the years, Professor Harry Brown is shown operating the x-ray diffraction unit and Professor Edward Sabbagh is shown with the electron microscope in Fig. 7 and 8, respectively.

Louis Block of this department is shown in Fig. 9 at the control panel of the spectrograph. He and this author are presenting a paper on "The Analysis of Fillers in Paper by Spectrographic Methods" at this meeting. We intend to indicate the special assistance this valuable instrument can be to the paper industry.

Textile Chemistry Division

It would seem that the many years of experience of this division with textile coloring problems could be applied to paper coloring as well. The recording spectrophotometer that Professor John H. Skinkle is shown operating in Fig. 10 is only one of the many research aids available to the capable staff of this division.

In the opposite vein, the problem of removing color from rag in the preparation of rag content papers should logically invite this staff to be of advice and assistance.

Plastics and Electronic Engineering

Two new departments, plastics and electronic engineering, have been established recently. At present the department heads, Russel Ehlers and Felix Palubinskas, respectively, are the only personnel.

These departments have not had time to progress to the point where they have specialized research equipment. However, both men are available on a short time basis for consultation. In the not-to-far-distant future, say 2 or 3 years, paper problems involving these fields can be worked out by th staff using equipment at Lowell Tech.

Fig. 10. Recording spectrophotometer

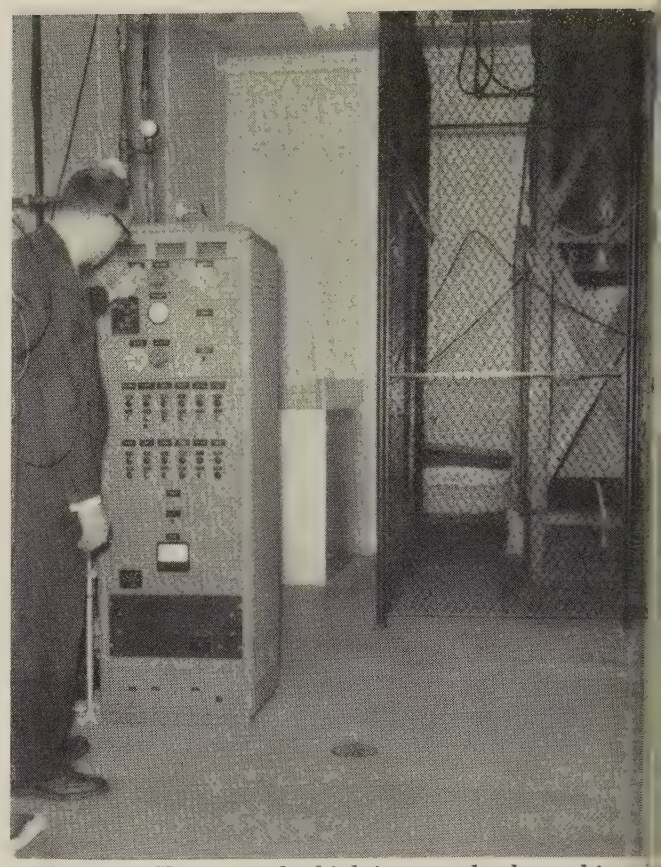


Fig. 11. Heavy weight-high impact shock machine

Special Facilities in the Research Foundation

Among the specialized instruments available in the R search Section of the Foundation is a heavy weight-high im pact shock machine capable of studying materials at impa velocities from 20 to 50 f.p.s. Adolph Katz, Technic Director of the Foundation's Research Section, is shown Fig. 11 with this machine.

Although this machine is presently being used to evalua various cushioning materials for the Air Force, it offers mar possibilities for research in the paper industry. Load-d flection data can be obtained on heavy-duty paper containe By means of high-speed photography it would be possible observe the manner in which various containers crush a absorb shock loads.

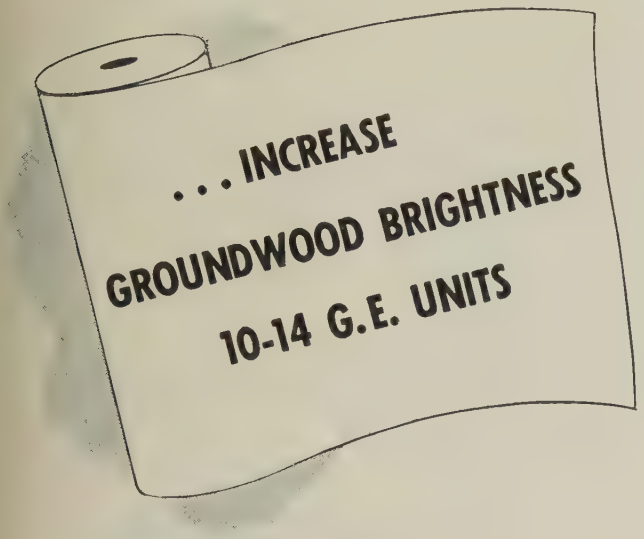
The Foundation has recently developed a special resistivi meter for evaluating antistatic agents applied to textile m terials. The problems of static electricity in the paper i dustry are quite similar to those of the textile industr Papers and fibers may be studied to predict the possibility static buildup during processing or printing. Studies may made on the resistivity of surface finishes at various humidit and temperatures (down to −30°F.) not only in line wi static electricity but the possibility of relating surface resi ance with other properties of the paper.

There are also available instruments of experimental str analysis, including loaded wire strain gages and a polarisco for photoelastic studies. Such equipment can be of gre value in machine design and analysis.

There have been many occasions in the past when there h been no test equipment available, or even designed. In tho events and at times when the job could be done at less e pense, the Foundation has called on Professor Arthur Ai worth to assist in designing and building the required pie in the well-equipped machine shop which is under his capa direction.

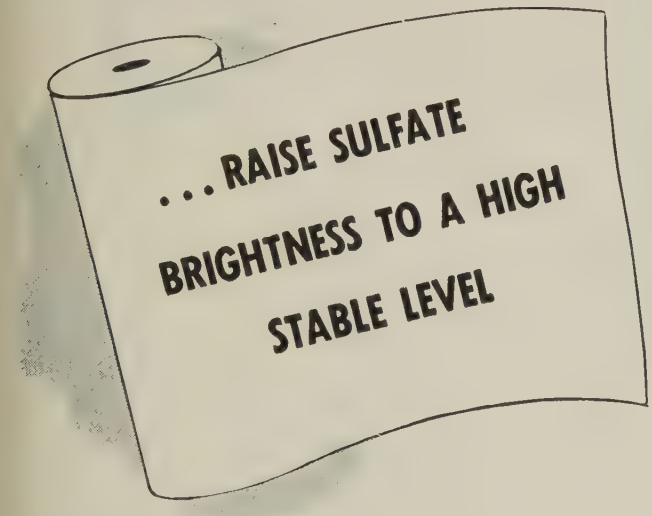
Bleach your pulp for brighter paper

with DU PONT PEROXIDE BLEACHING PROCESSES . . .



No other process gives you such high stable brightness levels—*increases of 10-14 G.E. units where needed!* Yet, Du Pont's Peroxide Bleaching Process preserves all the desirable features of groundwood, including high opacity, good formation and excellent printing properties.

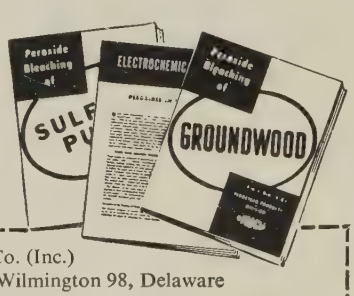
SEND FOR OUR NEW BULLETIN P62-1054, "High-Brightness Bleaching of Groundwood." It describes how you can increase your groundwood brightness for brighter, more profitable papers. Mail coupon below for your copy of this bulletin and descriptive booklet.



Meet today's demand for high-quality bleached pulp with the Du Pont Peroxide Process. You can bleach sulfate pulp to high, *stable* brightness values, retaining good strength characteristics.

Peroxide treatment improves brightness retention and color stability of bleached pulp. In most cases the Du Pont process can be operated in existing equipment, with only a small investment for storing chemicals.

SEND FOR OUR DESCRIPTIVE BOOKLET on "Peroxide Bleaching of Sulfate Pulp." Mail coupon below.



DU PONT PEROXIDES are available for prompt delivery from conveniently located manufacturing plants. Du Pont's modern plants and facilities assure you a dependable supply of top-quality peroxide for your bleaching needs.

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"We need a better machine speed indicator..."

said one mill in a recent survey on process instrumentation

THE Taylor Speed Transmitter is an accurate and efficient method for measuring the speed of rotating equipment, such as Paper Machine Couches, Presses, Dryers, Calenders and Winder Rolls, Turbines, etc. Pneumatically operated, it's rugged, simple, easy to adjust and adaptable to standard pneumatic receivers or controllers. Its design is based upon a direct proportional relationship between speed and force which results in fine, hair-line accurate performance and true speed indication at any time. Ask your Taylor Field Engineer about this proven, versatile instrument, and write for **Bulletin 98207.**

Taylor Instrument Companies, Rochester, N.Y., and Toronto, Canada.

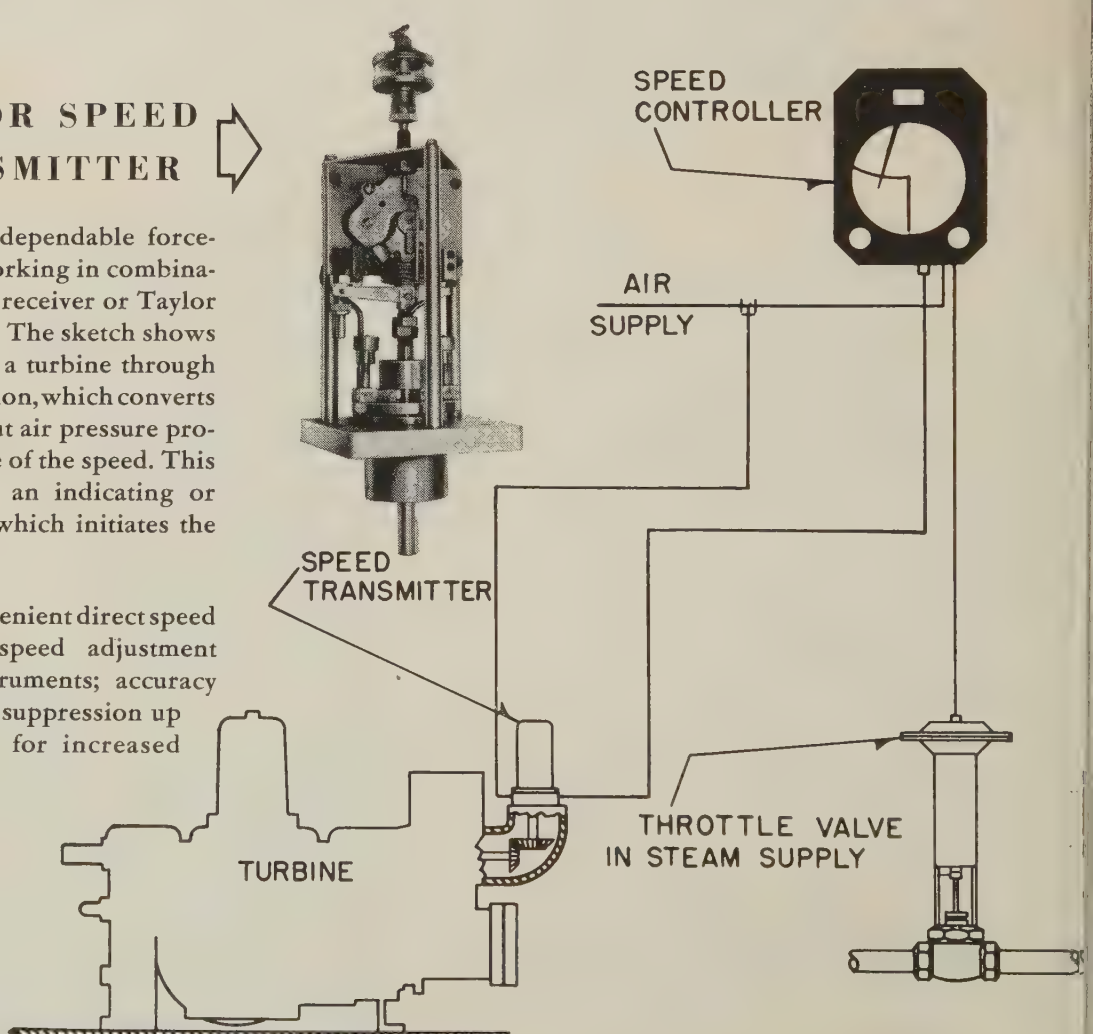
"And here you are!" *says Taylor*

TAYLOR SPEED TRANSMITTER

How it works: It is a dependable force-balance transmitter working in combination with a pneumatic receiver or Taylor FULSCOPE* controller. The sketch shows transmitter, driven by a turbine through a positive gear connection, which converts speed directly to output air pressure proportional to the square of the speed. This signal is received by an indicating or recording controller which initiates the corrective action.

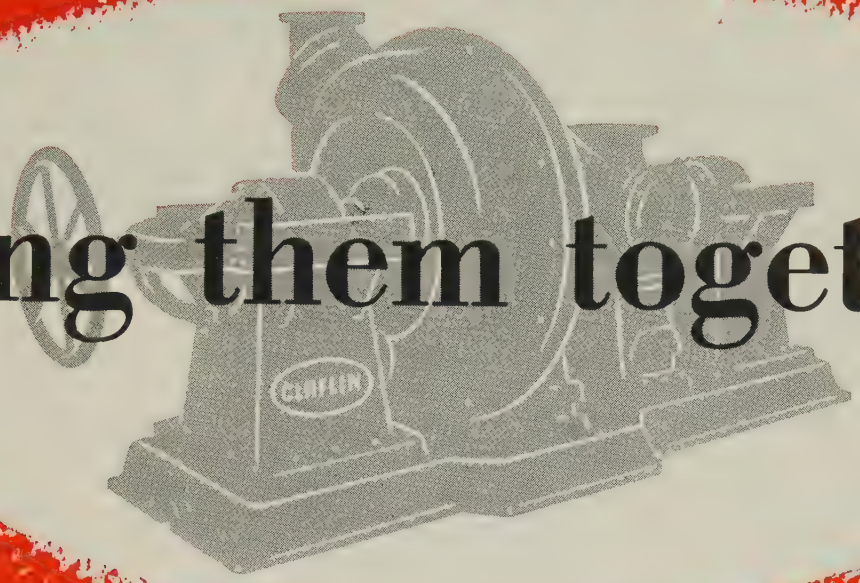
Some advantages: Convenient direct speed readings; direct-set speed adjustment with controlling instruments; accuracy to plus or minus .5%; suppression up to 90% of top speed for increased readability.

*Reg. U.S. Pat. Off.



Taylor Instruments MEAN ACCURACY FIRST

bring them together*



*That's what this red symbol ⊃ means in the world of printing. In paper making it would apply to CLAFLINS as pre-refiners and refiners, complementing the Jordan or other final stock treating units.

Now, for the first time, CLAFLIN refiners are built by EMERSON, a name respected for precision refining equipment.

Greater tonnage and better stock treatment are proved results when you "bring together" CLAFLINS and final stock treating units.

- Claflins *are used as continuous beaters and refiners;*
- *for separate one pass prebeating of soda, sulphite and kraft pulps;*
- *in the Pulp mill for defibering before washing.*

With low installation and maintenance costs CLAFLINS provide the perfect solution for pre-refining of stock. EMERSON supplies CLAFLIN machines and CLAFLIN fillings to fit all types of primary refining and beating operations.

Ask your EMERSON representative for further information on these versatile refiners.

Claflin CONTINUOUS BEATERS AND REFINERS

THE EMERSON MANUFACTURING COMPANY

Division of John W. BOLTON & Sons, Inc.
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My mill pays dividends, too!

"IT'S not a big mill. In fact, it's a little mill. But it pays big dividends. Since installing Valley Equipment — we can run *complete pulp tests* and save the high cost of mill experimentation. We know, at all times, the quality characteristics of our pulp — and thus maintain continuous control of paper quality. It saves a lot of money — and we're turning out better paper!"

If your mill is not equipped with a Valley Equipment Laboratory — write for our comprehensive bulletin on this important phase of mill operation.

VALLEY IRON WORKS CO.
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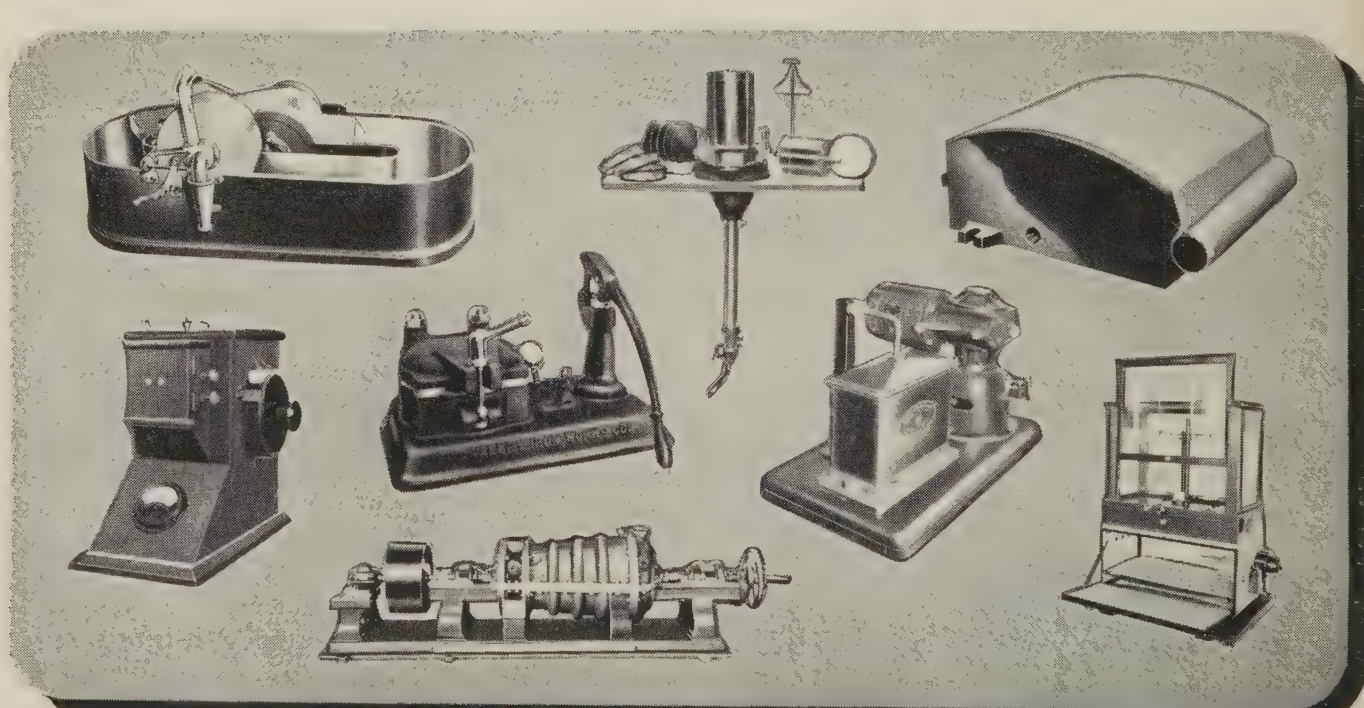

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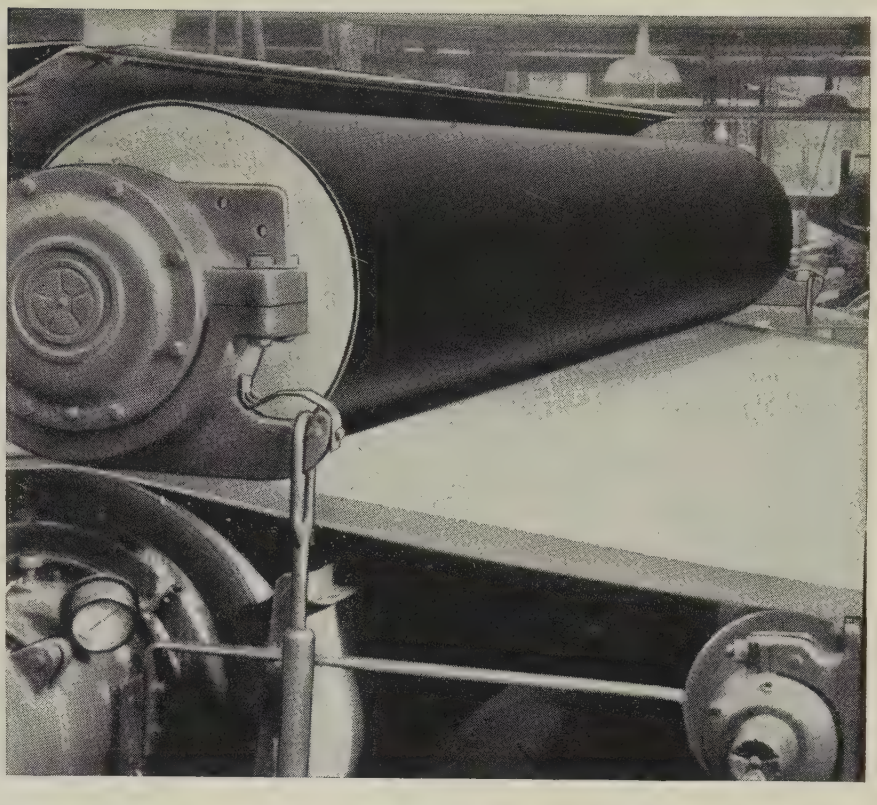
TO SPEED PRODUCTION AND REDUCE MACHINE DOWNTIME

Look for a company that has developed a superior rubber to metal bond . . . a company with the experience and facilities to custom-compound roll covering to your specific requirements.

Cracking, hardening, corrugation, or separation of the rubber from the metal roll core are frequent sources of trouble with ordinary rubber covered rolls . . . resulting in costly losses in production, quality and schedules. Rubber covering for your rolls should be compounded to prevent these causes of machine downtime in your *particular* operations. The rubber should also be permanently bonded to the metal to prevent cover separation that ultimately leads to roll failure. Make certain the company that covers your rolls has the ability to produce the correct rubber compound for your needs . . . the equipment to vulcanize and grind your roll covering to your specifications . . . the facilities to handle your job regardless of size.

Specify rubber covered rolls custom-made by experienced roll covering specialists . . . specify Manhattan Rubber Covered Rolls.



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Manhattan roll covering specialists have eliminated the major causes of expensive machine downtime to give you "More Use per Dollar" with Manhattan Rubber Covered Rolls. An exclusive Manhattan process provides an inseparable bond of rubber to metal to eliminate separation of the rubber cover from the metal roll core. Manhattan Rubber Covered Rolls are compounded to give you high-speed, uniform production under all working conditions . . . they won't harden, crack, corrugate or oxidize.

Custom-made to meet your specific working requirements, they assure permanent, uniform and correct density. Manhattan's modern precision roll grinding and vulcanizing facilities enable experienced craftsmen to handle the largest rolls in use today . . . and insure accuracy of dimension within .002". Call an R/M roll covering specialist to discuss your requirements. He will show you how you can get long, trouble-free service—"More Use per Dollar"—with Manhattan Rubber Covered Rolls. RM 519

ROLL COVERING PLANTS AT PASSAIC, N. J. — NEENAH, WIS. — NORTH CHARLESTON, S. C.

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

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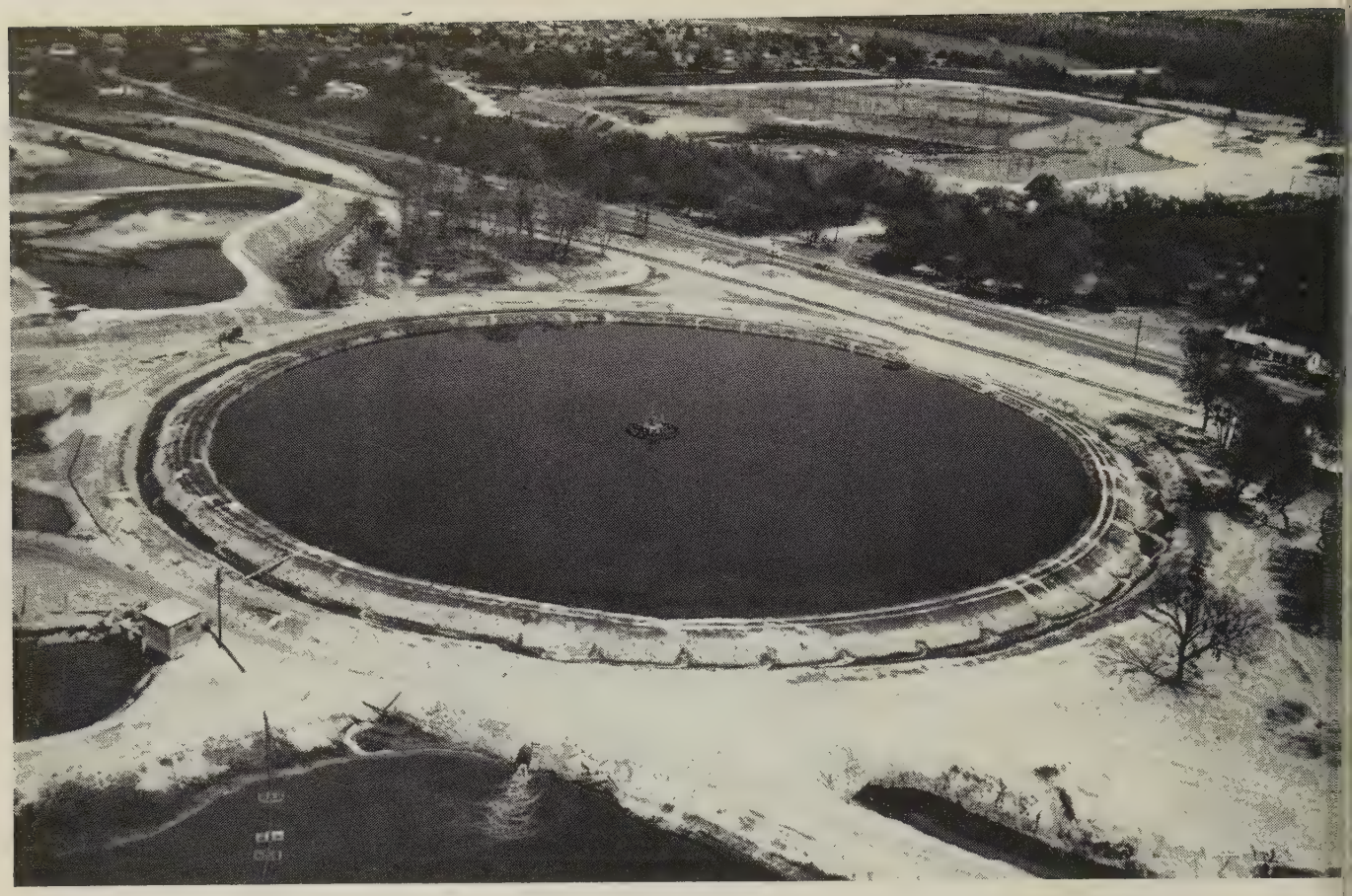

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300′ dia. Dorr Clarifier installed in 500′ earthen basin at a Southern paper mill removes approximately 90% of suspended solids . . . with substantial reduction in B.O.D. . . .

Simplicity and relative economy sum up this unusual waste treatment installation which went into operation in mid 1953. Primarily installed for suspended solids removal from general mill effluent, it is also doing a good job of B.O.D. reduction.

This Dorr Clarifier-earthen basin team is suited principally for use as a primary treatment unit. Additional treatment steps can be added as needed, without affecting the initial Clarifier installation.

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Physical Properties of Papers from Synthetic Fibers

JAMES K. HUBBARD, FRANKLIN H. KOONTZ, JOHN R. McCARTNEY, and ROBERT A. A. HENTSCHEL

The outstanding functional properties of the newer synthetic fibers, such as their resistance to degradation by strongly corrosive chemicals, molds, bacteria, sunlight, heat, moisture, and their high strength, flex endurance, and abrasion resistance prompted a study of methods for converting them into papers. Outstanding physical properties in terms of fold endurance and strength have been obtained with papers retaining the other desirable properties of the synthetic fibers. Methods of bonding, which are critical to success, are discussed, together with information on the effect of fiber length on properties, dimensional stability to humidity changes, and the strength of sewn seams and heat-sealed joints. It is concluded that synthetic fiber papers represent valuable potential products for the paper industry in uses requiring properties which cannot be obtained with cellulosic papers.

THE last 20 years have seen the development of a number of completely synthetic fibers. In the textile field their functional properties have led to substantial and growing use supplementing the well-established natural fibers. The commercially available synthetic fibers cover a wide spectrum of properties. Nylon has an outstanding combination of high strength, toughness, abrasion resistance, and flex endurance. These result in a long useful life in such difficult textile applications as men's socks. "Orlon" acrylic fiber has outstanding durability to outdoor exposure, molds, acids, and other chemical attack. Fabrics of Orlon acrylic fiber can be buried in the ground for months with no significant loss in strength, and can be used to filter such corrosive liquids as 50% aqua regia at 120° F., with little effect on the fabric strength after 3 weeks' exposure. "Dacron" polyester fiber has good resistance to heat, together with high strength, high modulus of elasticity, and flex resistance. Fabrics of Dacron polyester fiber have been used successfully for dust filtration at 350° F. All of these synthetic fibers have very low moisture pickup, and thus lose little if any strength when wet, retain their shape through washing, and dry very quickly. The easy washing and drying performance of garments from these fibers, for example, is too well known to need description.

The outstanding functional properties of these synthetic fibers has prompted an investigation of their characteristics in paper form, since it would be expected that papers reflecting their functional properties might well point the way to further diversification in the already diversified paper industry. In the past there has apparently been little success in making papers from these fibers, either alone or in blends with cellulose. This has been due in part to the difficulties in bonding synthetic fibers into sheets in such a way as to take advantage of their strength. Some of these difficulties have been overcome in the work described here, and synthetic fiber papers with radically new and outstanding properties have now been prepared on a laboratory basis. Some of these papers have fold endurances, for example, of 200 times those of the better cellulose papers, and many have tensile strength, elongation, tear, and burst values 3 to 10 times those of a kraft paper of comparable thickness. At the same time, the hydrophobic character of these fibers is favorably reflected in the properties of the sheets when wet. While the cost of wholly synthetic fibers is, and probably will remain, significantly higher than cellulose, these costs can be expected gradually to come down as quantities used increase, and as synthetic fibers might eventually be tailored specifically for papermaking if it appeared that this end use offered volume outlets. There is even now an increasing quantity of synthetic fiber waste available from textile mills which represents a present potential source of supply at prices well below current selling prices for the virgin fiber.

FIBER PROPERTIES

This first preliminary report will discuss the papers which have been made in the laboratory, their characteristics, and the methods used to make them. The

Table I. Properties of Synthetic Fibers

	Nylon T-200	*"Orlon" acrylic fiber T-81*	*"Dacron" polyester fiber T-5499*	*Cotton*
Tensile strength, g./denier[a]	5.0	5.3	3.8	3
Elongation, %	27	16	38	6
Ratio, tensile strength wet/ tensile strength dry	0.85	0.95	1	1.2
Moisture regain, % at 65% R.H.	4	1.5	0.1	7
Dimensional stability, % length change from 0 to 100% R.H.	2.5	0.5	0.1	0.2
Electrical properties	Good	Excellent	Excellent	Poor
Resistance to Solvents, oils	Good	Excellent	Good	Excellent
Acids	Fair	Good	Good (weak)	Poor
Alkalies	Good	Fair	Good (weak)	Fair
Microorganisms and insects	Good	Excellent	Excellent	Poor
Ultraviolet light and weather	Good	Excellent	Good	Fair
Oxidizing agents and bleaches	Good	Fair	Excellent	Fair
Abrasion resistance	Excellent	Good	Good	Good

[a] Denier—a measure of cross-sectional area, specifically grams weight per 9000 meters of fiber. Pounds per square inch = grams per denier × 12,800 × fiber density.

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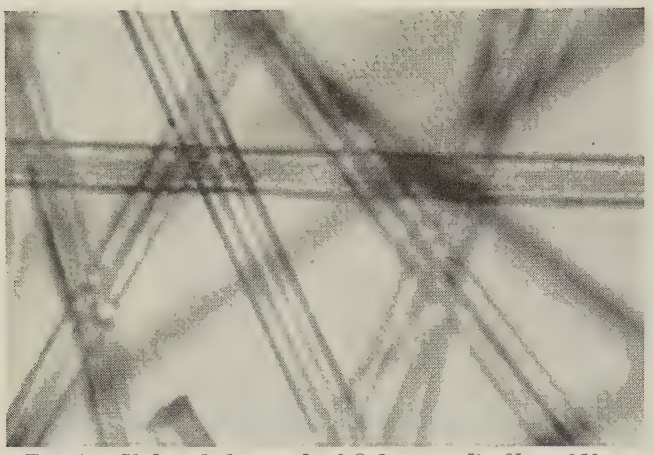

Fig. 1. Unbonded waterleaf Orlon acrylic fiber; 250×

synthetics which have been used in this work are nylon type 200 polyamide fiber, Orlon* type 81 acrylic fiber, and Dacron* type 5400 and type 5600 polyester fiber. The properties of these fibers, together with cotton, as a representative cellulose fiber, are summarized in Table I. Inspection of this table shows the synthetic fibers to be generally high in strength, low in moisture absorption, and high in resistance to chemical and biological degradation. As a class, they are also characterized by uniform fiber diameter and cross section, and high flex resistance. It is apparent that these properties are distinctly different from those of cellulose and should lead to papers or paperlike products of unique properties.

FIBER-TO-FIBER BONDING

To use these synthetic fibers for a successful paper product, one immediately confronts the problem of fiber-to-fiber bonding. Synthetic fibers do not react to beating in the same way as does cellulose. When cellulose fibers are beaten, the individual fibers fibrillate, and the strength of the cellulose paper then arises from bonding of the fibrils in the subsequent drying. Synthetic fibers, on the other hand, do not generally fibrillate when beaten. Instead, they are simply reduced in length, leading to no mechanism for subsequent bonding. For this reason, the key to successful papermaking from synthetic fibers lies in effecting the bonding step. Two such bonding methods have been developed for nylon, Orlon acrylic fiber, and Dacron polyester fiber. One of these is identified as "salt bonding," the other as "synthetic polymer bonding." With salt bonding, the binding agent comes from the fiber itself so that completely homogeneous paper result: the binder and fiber are of identical chemical makeup. With synthetic polymer bonding, a second binding constituent is added to the waterleaf and serves to hold the fibers together.

In salt bonding, use is made of the fact that water solutions of certain salts at high concentrations are swelling agents or solvents for the fiber-forming organic polymers, but become nonsolvents when dilute. When a waterleaf is impregnated with such a dilute salt solution and the water subsequently evaporated, the salt solution concentrates, and tends to localize preferentially at the crossover points of the fibers, ultimately becoming sufficiently concentrated to lead to solution or gelatinization of a small portion of the fiber surface at these crossover points. Finally, on complete evaporation of the water, the polymer reprecipitates and bonding of the fibers has been completed. The paper sheet can now be safely washed free of salt and redried. This process is illustrated in the photomicrographs of Figs. 1 and 2. Figure 1 shows an unbonded waterleaf of Orlon acrylic fibers. The smooth, unfibrillated fibers are simply interlaced, with little mechanical and no chemical bonding of the structure.

When such a waterleaf is impregnated with an appropriate salt solution and dried, bonds are formed as illustrated in Fig. 2. At points where the interlacing fibers touch one another, the process of solution and reprecipitation has produced the bonds pointed out by the arrows. In the regions where the fibers are not in physical contact, no joining takes place and the fibers are substantially unaffected by the bonding treatment which generally affects only the surface layers of the fiber. A number of common salts have been found effective in producing such bonding. These are tabulated in Table II. In general, they are applied from solutions containing 2 to 10% salt. The exact concentration preferred depends on the fiber used and the conditions of temperature and pressure in forming the sheet.

In the synthetic polymer bonding process for these papers, another mechanism is involved. The waterleaf to be bonded is impregnated with a dispersion or solution of the binding polymer. On evaporation of the carrier the polymer which it contains again tends to concentrate at the crossover points of the fibers by capillary action, being deposited at these points and remaining there after removal of the carrier. The bonding process is then completed by heat and pressure. In general, the preferred polymeric binders are somewhat elastic in nature and generally bear some similarity in chemical constitution to the fibers being bonded.

Table II. Salt Binders for Synthetic Fiber Papers

Fiber	*Salt*
Nylon	$CaBr_2$, LiBr, $Ca(CNS)_2$, $Mg(CNS)_2$
Orlon acrylic fiber	LiBr, $CaBr_2$, $Ca(CNS)_2$, $Mg(CNS)_2$
Dacron polyester fiber	$Ca(CNS)_2$ or $Mg(CNS)_2$

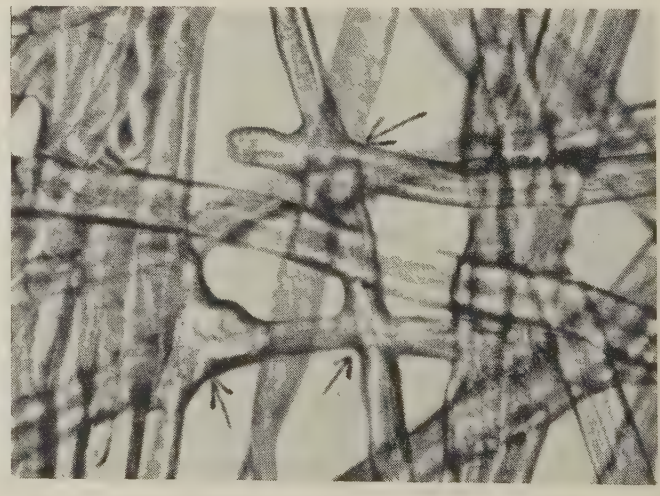

Fig. 2. Bonded waterleaf Orlon acrylic fiber; 250×

* Du Pont trademark.

Table III. Polymeric Binders for Synthetic Fiber Papers

Fiber	*Binder*
Nylon	Polyamide binder
Orlon acrylic fiber	Polyamide binder, "Geon"[a] 576, "Hycar"[b] 1551, "Chemigum"[c]
Dacron polyester fiber	Polyester binder

[a] Trademark for B. F. Goodrich Co. synthetic latex.
[b] Trademark for B. F. Goodrich Co. synthetic latex.
[c] Trademark for Goodyear Tire & Rubber Co. synthetic latex.

Table III shows examples of polymeric binders which have been used successfully.

These were all applied from 5 to 10% aqueous dispersions with the exception of the polyester binder, which was applied from a 1 to 3% solution in chloroform. The polyamide and polyester binders were specifically formulated for this use to develop the desired paper properties when used with the indicated synthetic fibers.

Conventional laboratory papermaking techniques were used for making the papers described in this report. Slurries from fibers cut to the desired length were formed in water in a Dynopulper* of about 15 liters capacity. Slurries of about 0.1% fiber by weight (more or less, dependent on the weight of sheet to be formed) were used. Since these fibers are somewhat difficult to disperse, approximately 0.1% of carboxymethyl cellulose or other thickener was added to the water to aid in forming the slurry. Waterleaves were formed from the slurry in a conventional sheet mold with an 8 by 8-in. screen. The waterleaves were rinsed to remove the carboxymethyl cellulose, impregnated with the bonding agent, and finally pressed at elevated temperatures in a Carver laboratory press to form the sheet.

Using the bonding and sheetforming techniques described, a series of papers with very unusual physical properties have been made. Table IV summarizes properties which were measured on a series of these papers, together with the process details of their preparation. As a reference point, the properties of a 50-lb. kraft paper control are also given.

Inspection of these values shows that synthetic fiber papers have outstanding properties in many respects. Noteworthy are the extremely high flux endurance and tear strength of the nylon paper and the generally high tensile, elongation, and burst strength of all papers.

* Trademark for Rice & Barton pulping equipment.

Table V. Effect of Salt Concentration on Properties
Fiber—Nylon type 200, 3 denier

% Salt in bonding solution	*Tensile, lb./in.*	*Elongation, %*
1% $ZnBr_2$	7.5	16.7
3% $ZnBr_2$	22.6	34.4
5% $ZnBr_2$	30.6	34.2
7% $ZnBr_2$	27.6	34.1
9% $ZnBr_2$	30.5	33.8
10% $ZnBr_2$	32.5	32.2

As would be expected, these properties will be affected in individual cases by the kind and amount of bonding agent and fiber, and the details of paper preparation. While all these variables have not yet been exhaustively studied, some illustrative information is available on the concentration of binding agent and on fiber length. Table V shows the effect of salt concentration in the binding solution on a nylon paper bonded with zinc bromide. It may be seen that the sheet strength rises as the concentration of salt in the bonding solution increases to about 5%, and then levels off. Thus the optimum salt content in this case was between 3 and 5%.

The effect of fiber length has been briefly investigated for a nylon type 200 fiber and the results are tabulated in Table VI.

The effect of fiber length is not great, and it appears that good properties can be achieved with relatively short fibers which are more readily dispersed to form slurries than the longer ones.

JOINING METHODS

The properties of these papers, particularly nylon, suggest that in many applications these papers could replace fabrics. Since in these uses, joining methods are important, some measurements have been made on the strength of sewn and heat-sealed joints. Table VII gives the properties of machine-sewn seams in a nylon paper bonded with polyamide binder resin dispersion in comparison to a cotton fabric. High-strength nylon sewing thread was used, so that, in all cases, the failure was in the sheet, not in the sewing thread. The utilization of strength in the nylon paper

Table IV. Properties of Synthetic Fiber Papers
Hard papers (pressed)

Fiber	*Bonding agent*	*Tensile, lb./in.*	*Elongation, %*	*Tear, g.*	*Burst, p.s.i.*	*Fold, cycles*	*Treatment*
Kraft[a]	.....	12	3	280	35	1,200	
Nylon type 200, 3 d.p.f.,[b] 3/8 in. length	10% $ZnBr_2$	32	15	1056	67	52,000	Impregnate, dry 120°C., press 160°C., 200 p.s.i., 30 sec., wash out residual salt
Nylon type 200, 3 d.p.f.,[b] 3/8 in. length	5% polyamide binder	33	33	1228	88	700,000 to 1,000,000	Impregnate, dry 120°C., press 160°C., 200 p.s.i., 30 sec.
Orlon[c] type 81, 2.5 d.p.f., 5/8 in. length	5% $Ca(CNS)_2$	31	6	298	67	51,000	Impregnate, dry 120°C., press 160°C., 200 p.s.i., 30 sec., wash out residual salt
Orlon[c] type 81, 2.5 d.p.f., 5/8 in. length	5% polyamide binder	29	15	246	116	65,000	Impregnate, dry 120°C., press 160°C., 200 p.s.i., 30 sec.
Dacron[d] type 5600, 2 d.p.f., 1/2 in. length	10% $Mg(CNS)_2$	22	8	384	132	68,000	Impregnate, press wet, 200°C., 200 p.s.i., 30 sec.
Dacron[d] type 5600, 2 d.p.f., 1/2 in. length	1.25% polyester binder	32	53	928	207	53,000	Impregnate $CHCl_3$ solution, dry R.T., press 160°C., 200 p.s.i., 30 sec.

All papers (including kraft) had a basis weight of approximately 60 lb. per TAPPI standard ream, 25 × 40—500, 6 to 7 mils thick.
[a] Union Bag & Paper Co., wet-strength, high water repellent, 6 to 7 mils thick, 50 lb. kraft.
[b] d.p.f.—denier per filament—a measure of fiber diameter, specifically, the weight in grams of 9000 meters of fiber.
[c] Trademark for Du Pont acrylic fiber.
[d] Trademark for Du Pont polyester fiber.

Table VI. Effect of Fiber Length on Properties

Fiber	Length	Tensile, lb./in.	Elongation, %	Burst, p.s.i.	Tear, grams
Nylon T 200, 1.2 den., bonded with 2% LiBr, pressed at 160°C., 200 p.s.i.	1/8	25.5	18	93	192
	1/4	33.2	20	91	224
	3/8	29	18	91	198
	1/2	29	18	89	184
	5/8	34	20	78	248
	3/4	40.6	20	88	250
	7/8	29.5	20	167	272
Nylon T 200, 1.2 den., bonded with 8% polyamide binder dispersion, pressed at 160°C., 200 p.s.i.	1/8	28	19	136	358
	3/8	33	21	133	544
	3/4	37	31	169	544

is greater than for the woven fabric on the basis of the percentage of the base sheet strength achieved by the seam. Nylon papers can also be joined by heat and pressure to form a heat-sealed joint. A 1/2-in. wide joint of this type developed 70% of the base strength of the sheet; a paper with a tenacity of 90 lb. per in. giving a 1/2-in. wide heat-sealed joint with a tenacity of 65 lb. per in.

DIMENSIONAL STABILITY

The dimensional stability of these synthetic fiber papers has been compared to three cellulose papers: a letter bond, a map paper (as used in the Coast and Geodetic Survey maps), and a tracing vellum. The dimensional changes of these papers were measured by a modified ASTM procedure, using 1/2-in. wide by 10-cm. long strips loaded with a 10-gram load. The samples were initially conditioned at 0% R.H. and were

Table VII. Strength of Sewn Seams—Nylon Paper

Method of loading sewn seam	Nylon paper, 2.5 oz./sq. yd., bonded with polyamide binder, resin dispersion 10%, pressed 160°C., 200 p.s.i.		Cotton fabric, 40 × 40 count, plain weave, 5.0 oz./sq. yd.	
	Strength, lb./in.	Seam strength, as % of base sheet strength	Strength, lb./in.	Seam strength, as % of base fabric strength
Base material	36	...	109	
	40	110	16	15
	14	39	14	13
	26	72	68	62
	27	75	72	66

Table VIII. Dimensional Stability of Synthetic Fiber Papers

Paper	Change in length, % between 35 and 90% R.H. First cycle	Subsequent cycles
Bond—ACS grade	2.9	2.1
Map—U. S. Coast and Geodetic Survey	1.1	0.7
Vellum—Keuffel & Esser 100% white rag	1.1	0.6
Nylon fiber—polyamide binder	1.8	0.2
Dacron polyester fiber—polyester binder	0.5	0.15
Orlon acrylic fiber—polyamide binder	0.5	0.2

then cycled between 35% and 90% R.H. for five complete cycles. Length changes were expressed as per cent of the initial length at 0% R.H. All samples showed a relatively large change on the initial cycle, followed by a smaller and constant change on subsequent cycles. All samples increased in length with increasing relative humidity. The cellulosic papers were measured in the cross-machine direction; the synthetic papers showed no fiber orientation. The results of this test are summarized in Table VIII.

POTENTIAL USES

The properties of the synthetic fiber papers reviewed in this report suggest many interesting new uses, uses which conventional papers cannot easily fill. Their high tear strength and flex endurance, together with the ease of sewing suggest replacement of industrial fabrics in such applications as heavy duty bags, tarpaulins, coated fabrics, abrasive cloths, tentings, etc. Their resistance to chemical attack suggests use in filtration of highly corrosive liquids, packaging of corrosive chemicals, etc. Their low moisture absorption, resistance to degradation by molds, bacteria and light, and dimensional stability suggest applications in map and tracing papers, and for important records and documents where a high order of permanence is necessary. The use of nylon papers, with their extremely high fold endurance and tear strength for currency papers is a very obvious possibility. In laminates for electrical uses, Dacron polyester fiber papers should contribute to good electrical properties. Obviously, there are many other fields of usefulness which have not even been suggested.

CONCLUSIONS

This report shows that papers with many unique properties can be made from the newer synthetic fibers. Such papers should supplement cellulosic papers where unusual strength, folding endurance, stability and resistance to chemical degradation are desired, and should permit papers to be used in many applications where fabrics are now required.

It should be repeated that the papers reviewed here have been prepared on a strictly laboratory basis. There are other problems which remain to be solved before the promise of these new materials can be commercially realized. The most important of these is is the development of methods for dispersing these synthetic fibers into satisfactory papermaking slurries which will be commercially operable on papermaking machinery. Secondly, technically suitable processes

for applying bonding agents in the papermill must be worked out. Research on these and other related problems is under way. Fortunately, these are problems to which the papermaker can contribute a wealth of know-how and experience. Close technical cooperation between the papermaker and the synthetic fiber manufacturer should expedite the development of a whole new line of synthetic paper products wherein each party contributes his specialized knowledge and background. The development of the modern tire over the past 15 years based on a synthetic fiber carcass is an example of such a successful cooperative effort. A similar opportunity can now be visualized as open to both the paper industry and the manufacturer of synthetic fiber in the coordination of their respective technologies.

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A Review of Digester Corrosion Causes

W. B. PARKER

Because of the increase in digester corrosion and the emphasis placed upon it in recent years there seems to be a feeling that the problem is a new one. Such is not the case as digester corrosion has been a serious problem for many years. Several causes of digester corrosion are outlined and discussed with solutions in some cases. There is still much work to be done before the complete answer is determined.

MANY of the recently presented papers on digester corrosion indicate, intentionally or otherwise, that the corrosion of digesters has become a real problem only within the past few years. Such is not the case, however, as the corrosion of sulphate digesters has been a cause of concern to many operators, and to the insurance inspector, for many years.

In a paper presented before the Annual Meeting of TAPPI at New York in 1930, William D. Halsey (*1*) of the author's company related an experience in one mill which resulted in the failure of a sulphate digester killing three persons, injuring four others, and causing property damage amounting to $150,000. Following that occurrence an investigation was made of insured digesters used in the sulphate pulp industry, the thickness being determined by drilling. Of 66 digesters investigated, varying in age from 1 to 35 years, corrosion was found in all of them, the reduction in thickness varying up to 68% of the original thickness. In a large number of cases, the corrosion was so severe that it was necessary to greatly reduce the operating pressure which in some instances amounted to virtual condemnation of the vessel.

The results of the investigation made at that time parallel to a great extent the results of more recent investigations of digester corrosion. In a majority of cases, it was found that the most serious wasting of metal occurred in the upper part of the digester with serious corrosion developing in a few cases near the bottom or in the cone section. The cause of the wastage was attributed to: (1) erosion as a result of the method of filling, (2) corrosion due to circulation of liquor and chips in the digester, and (3) the possibility of the major part of the corrosion being the result of chemical action of the cooking liquors used.

It is interesting to note that the analysis of digester corrosion at that time took into consideration the corrosion attributed to the chemical action of the sulphate process which would result in a more or less general corrosion throughout the vessel and, in addition, the effect of filling methods, circulation of chips and liquor, and other conditions which may result in accelerated localized corrosion.

During and following the war years, it was noted that digesters in the sulphate process were apparently corroding much more rapidly than in the past and that their life expectancy was being cut down considerably. As this phenomenon was noted particularly in connection with newly installed digesters, where in some cases the service life was from 2 to 5 years, the immediate tendency was to blame the shorter life upon a change in the steel of which the digesters were constructed. This attitude was apparently justified, as in many cases older digesters in the same mill were still giving satisfactory service while some of the newer digesters had to be replaced after a relatively short period of service.

As a result of the apparent serious increase in corrosion and the shortening of the life of kraft digesters, the Digester Corrosion Subcommittee was appointed by TAPPI to study the problem and to determine, if possible, the cause of the corrosion and the probable corrections.

It was immediately apparent that adequate records had not been kept in the past to determine the actual causes of the shorter life of the digesters or the reason for the apparent more rapid corrosion. Fortunately, at about the time the Digester Corrosion Subcommittee was appointed, the use of the audigage was becoming more common, and several mills were building up inspection records and thickness readings on their digesters. These records have been of great value to the committee.

The work of the Digester Corrosion Subcommittee in the past few years has not provided a complete answer to the problem, but many important results have been achieved to date.

In this paper will be discussed some of these achievements and possible areas for future study.

MATERIAL OF CONSTRUCTION

The great majority of sulphate digesters are constructed of carbon steel. As stated above, it was the more rapid corrosion of these carbon steel digesters

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in recent years that initiated the investigation as to digester corrosion causes.

In an attempt to determine whether or not the increased corrosion rate was caused by changes in steel composition or chemistry, E. W. Hopper (*2*) investigated, in the laboratory, a number of steel samples that were taken from digesters that were given either good or poor service life. In addition to the laboratory work, Mr. Hopper made a number of inspections of digesters in the field. Based upon the result of the laboratory work and the digester inspections, Mr. Hopper reported that:

1. Steel chemistry does not appear to be a major factor influencing service life.
2. Steel types i.e., rimmed or killed, does not seem to be the definite answer to long service life.
3. The high carbon-silica killed steel does seem to have a greater tendency toward rapid attacks.
4. The soundness of the steel may have a marked influence on the corrosion or erosion rate. This soundness may be affected by steel chemistry.

While steel chemistry does not appear to be a major factor influencing digester life, it has apparently been determined over a period of years that chemistry does have some effect on the resistance to corrosion of steel. In 1931 C. Benedicks (*3*) pointed out that steel with a higher carbon content is less resistant to corrosion from sulphate liquor than steel of a lower carbon content. This also agrees with work by C. G. VonEssen (*4*) in a paper published in 1950, and with work by Lennart Ruus and Lennart Stockman (*5*) as a result of observations and laboratory work which was the basis of a paper in 1953. Ruus and VonEssen also agree that steels containing higher amounts of silicon are more susceptible to corrosion.

Huseby and Scheil (*6*) also showed that silicon was detrimental, determining that from about 0.20 to 0.74% silicon the corrosion rate is directly proportional to the silicon content. This effect of silicon in the metal was also noted to seriously affect welds which contain high total silicon.

INCREASED PRODUCTION

There is little doubt but that one of the major reasons for increased corrosion of sulphate digesters and the resultant shorter life is increased production. During the war years and immediately thereafter there was a tremendous increase in the demand for paper products. To meet this demand it was necessary for the mills to increase production schedules which resulted in changes in the chemistry of the cooking liquor and an increase in operating pressures and temperatures to allow shorter cooks. It would be expected that these changes would result in increased corrosion and shorter digester life.

To better determine the effect of the shorter cook several American mills have analyzed their digester experience on the basis of corrosion rates per 1000 cooks rather than per year, as has been the normally accepted practice. On that basis it was found that the corrosion rates do not vary greatly over the corrosion rates previously experienced. This approach is also borne out by experience in Norwegian paper mills as reported by Roald (*7*). Maximum corrosion rates per year were calculated on a number of digesters in Norwegian mills and it was found that the rates varied considerably. However, upon recalculating on the basis of corrosion rate per 1000 cooks, it was found that the corrosion rates at the various mills agreed quite closely.

On the basis of this experience it would appear that to determine experience accurately with sulphate digesters over a period of years it would be better to report corrosion rates both on the basis of each 1000 cooks, and on the basis of a year's operation. As a logical means of comparison undoubtedly the rate per 1000 cooks would prove to be a better approach.

CHEMISTRY OF COOKING LIQUOR

The chemistry of the cooking liquor is probably the most important single phase of digester corrosion causes to be further investigated. Considerable work has already been done on investigating the effect of changes in chemistry of the cooking liquor, however, it appears that much additional work needs to be done before any definite conclusions can be reached.

In some cases there have been disagreements as to the effect of certain chemicals in the cooking liquor and it appears that even minor changes in some of the chemistry may have a great influence on the corrosiveness of the liquor. Careful study on the part of plant chemists will undoubtedly disclose conditions that result in active corrosion.

E. W. Hopper in a paper presented at the February, 1954, meeting of TAPPI in New York made the following conclusions, based upon extensive laboratory experiments on many samples of white liquor.

1. Cooking liquors may vary greatly in their inherent corrosiveness.
2. White liquor has much greater effect on corrosion rates than steel chemistry and type.
3. Higher caustic soda content does not increase corrosion rates.
4. Higher sodium sulphide content increases corrosion rates.
5. Increased carbonate content does not increase corrosion rates.
6. Increased sulphate content reduces the rate of attack slightly.
7. Increased chloride content increases the rate of attack slightly.
8. Some other chemical compounds in the white liquor, not reported in the normal chemical analysis, have a great influence on corrosion rates.
9. Air in the liquor increases the corrosiveness.
10. Deaeration, by boiling or flushing, reduces the rate of attack.
11. A very careful and thorough chemical study should be made of liquors showing excessive corrosion rates as well as low corrosion rates. This should cover not only the normally checked components but also the complex sulphur compounds. The presence of oxidizing and reducing compounds should be noted. The gases present in the liquor should be checked.

Other investigators have found that the effect of certain chemicals in the cooking liquor has a marked effect.

VonEssen (*4*) reports that laboratory tests showed that increased sulphidity speeded the corrosion in general.

Benedicks (*3*) reported that analysis of scale from digesters and pipes which had shown considerable corrosion was found to be practically all calcium carbonate, with a silicon dioxide content of approximately 0.7%. Scale taken from a vessel that showed no corrosion in the same mill consisted of calcium carbonate but con-

tained a high silicon dioxide content of approximately 9.7%. From this study he drew a conclusion that a high percentage of silicon dioxide in the vessel would probably result in the formation of a protective scale that would prevent corrosion. Mainly on the basis of Benedick's observation, J. C. Hair and A. W. Duskin (*8*) conducted experiments in digesters at Crossett Paper Mills attempting to deposit a protective coating on the digester surfaces. The experiment proved unsuccessful and the authors indicated that while they do not claim that it is impossible to form a protective scale in digesters by use of silicon, they did prove that the particular process attempted by them would not form such a protective scale.

Lennart Stockman (*5*) reports that it is general experience that introduction of spray-type recovery furnaces had led to an increase in digester corrosion. This apparently is caused by the higher sulphidities obtained with such recovery units, since an increase in the sodium sulphide content of the white liquor is known to increase the corrosion rate. Stockman also demonstrated that an increase in the sodium thiosulphate content from zero to 10 grams per liter leads to a nearly threefold increase in the corrosion rate. The thiosulphate content of the white liquor originates partly from the smelt and is partly produced by air oxidation of the sulphide during liquor preparation and storage. Examination of these stages of operation with a view toward the possibilities of reducing oxidation might well be in order.

As a result of considerable laboratory work and actual experience in plant digesters, John Hassler of the West Virginia Pulp & Paper Co. reported to the Annual Meeting of TAPPI in February, 1954, that the extent and often the nature of the effect of caustic liquors containing sulphidity depends on the form of the sulphidity. When polysulphides provide the major portion of the sulphidity the corrosion attack is slight. When the sulphidity consists entirely of sodium monosulphide (Na_2S) active corrosion results. When the sulphidity consists of a mixture of mono and disulphides, under some conditions the liquor will be more corrosive than with monosulphide; however, under other conditions it may not be as corrosive. Hassler also reported that the digesters at the Tyrone mill of West Virginia Pulp & Paper Co. had operated for approximately 28 years without evidence of serious corrosion. During that period, the sulphidity (3 to 8%) in the cooking liquor had been supplied by dissolving sulphur in caustic soda liquor. In January, 1952, the source of the sulphidity was changed to a by-product sodium sulphide and by the end of that year it became evident that the corrosion was then occurring at an excessive rate. This situation became the subject of an immediate investigation and since a change in the source of the sulphidity appeared to be the probable cause, that area was investigated.

It is known that elemental sulphur cooking liquors contain polysulphides (Na_2S_n) whereas the sulphur in by-product sodium sulphide is present entirely as monosulphide (Na_2S). To explore this aspect, a study was made of polysulphide prepared by other methods. Polysulphide formed by adding sulphur to sodium monosulphide was added to caustic liquor and the resulting cooking liquor was noncorrosive.

It seems evident that considerable additional study is needed to determine the reason for the varying corrosiveness of cooking liquors.

CHIP IMPINGEMENT

A relatively common cause of digester corrosion, or to be more exact, erosion, is chip impingement on the surfaces of the digester during the chip filling operation. This action causes wear of the surfaces resulting in the removal of any protective scale that may have formed. The removal of this protective scale may result in accelerated corrosion for a time in this area of the plate when the digester returns to service. This condition can be corrected by using care in the filling procedure to determine that the chips do not impinge directly on the digester surfaces.

CHIP PILE CONTOUR AND LIQUOR CHARGING

The importance of a proper filling procedure is emphasized by Flynn, Richter, and Snyder (*9*) in their discussion of "hot plate boiling."

"Hot plate boiling" is the result of liquor splashing on hot digester surfaces and boiling off because of the relatively high temperature of the digester plate in that area. This action is usually caused by the method of filling the digester. In those cases where this phenomenon has been noted, the chips and liquor are both admitted through the stock opening in the top of the digester. The chips enter the digester in such a manner that an off-center chip cone forms and the incoming liquor strikes on the side of this cone and splatters against the digester wall surfaces. Assuming that the digester is filled shortly after having been blown, the wall surfaces will be at a considerably higher temperature than the liquor and consequently the liquor boils off. This action destroys the protective film or coating on the digester shell and results in accelerated wastage.

This condition was definitely proved by the authors of the above mentioned paper, to cause serious corrosion to the digester involved and it has been shown at other locations to affect carbon steel digesters in the same manner. The phenomenon was first noted in a digester lined with type 405 alloy.

This hot plate boiling action is also reported by Roald (*7*) in a carbon steel digester at a Norwegian mill.

In any case where corrosion is noted to be occurring on a digester that might possibly be the result of hot plate boiling, a careful study should be made and the filling operation changed so as to prevent the incoming liquor from striking the relatively hot plates. This has been accomplished in some cases by changing the liquor inlet to the bottom of the digester so that splashing is eliminated. Partial correction may be made by installing deflection plates on the liquor inlet nozzle so that the liquor will be deflected into the chip stream thus controlling the splashing action.

Serious erosion and corrosion have resulted in many instances from direct impingement of the liquor on plate surfaces. Care should be taken to determine that neither the chips nor liquor directly impinge upon digester surfaces in such a manner that erosion will result.

LIQUOR CIRCULATION

It is known that the paths of circulation established

within the digester as the result of the flow of chips and liquor may cause corrosion of those areas. It appears that variations in the way the chips pack during filling result in voids or areas of loosely packed chips so that liquor circulation develops through these areas. Liquor impingement on the steel surfaces removes the protective film and corrosion results. A study of these conditions may point to changes in the filling and cooking methods which will prevent serious corrosion from this cause.

When spray nozzles are provided in the top of the digester they should be carefully checked at the time of each shutdown to determine that they are not arranged so that impingement on the shell or head surfaces will result. Impingement from this source may result in rapid wasting of the metal surfaces.

DIRECT STEAMING

Steam erosion or corrosion as a result of steam washing the digester surfaces may occur in direct steaming digesters. This influence, however, is small and can usually be easily corrected by redirecting the nozzles so that direct impingement of the steam on the digester surfaces will not occur.

It is known that a high oxygen content in the cooking liquor is likely to increase corrosion. Recently, one investigator recommended that the chips be presteamed in the digester to remove oxygen before adding the liquor, so as to reduce the oxygen content of the liquor. This operation should be used only after careful study, as Hassler reports, on the basis of laboratory experiments, that when chips were presteamed, that particular cook was found to be highly corrosive. It appears that the heat of the steaming operation released organic acid from the wood which penetrated the thin alkaline film on the digester wall, exposing the steel to corrosion.

TEMPERATURE DIFFERENTIAL IN METALS

Digesters that are located in the plant near a window or in other locations where they are exposed to drafts have been found to be more subject to corrosion. This is apparently due to the contraction and expansion as a result of temperature changes breaking away the protecting scale on the digester surface, exposing the surface to the corrosive effect of the cooking liquor. This condition can be corrected by properly insulating the digesters, a practice which has become more or less standard.

It is also possible to cause damage to the digester by thermal shock on the internal surfaces, resulting from the method of admitting the cooking liquor. In addition to the effect of "hot plate boiling" some mills have experienced cracking in areas where the liquor strikes the relatively hot plates of the digester causing quench cracking. It is possible that cracking of this type occurs only in certain digesters where the chemical composition of the steel is such that it is subject to cracking.

In any case, it is a relatively simple matter to protect digesters against the effects of temperature changes which may result in accelerated corrosion. A study of filling and operating procedures will usually disclose the cause and probable method of correction.

UNUSED FITTINGS

Serious localized corrosion has occurred at liquor circulation inlets, liquor strainers, sample outlets and thermometer elements, as well as at unused fittings that have been improperly blanked off. Corrosion from this cause can be easily spotted, as normally it will occur just below these openings, wearing channels in the digester shell. While corrosion of this type may not be serious enough to shorten the life of a digester, it frequently does result in relatively expensive repairs.

Installation of the normally used fittings should be such that they will not cause serious corrosion, which generally would require that they be designed to enter the digester at an angle downward rather than horizontally. Installation in this manner will prevent the accumulation of stock or liquor at such openings, which may cause corrosion as a result of the liquor dripping down the side of the vessel during idle periods. This same comment will apply to unused openings which should be blanked off on the inside of the vessel, providing a smooth surface.

GALVANIC EFFECT

There seems little question but what galvanic action does affect the corrosion rate of digesters. Experiments by Hopper and Hassler indicate that they do affect corrosion, however, their studies have not been complete enough to draw any real conclusions. Hopper did find that the film effect on a digester may be increased by cathodic treatment and that too high a cathodic current density destroys the film formed due to gas evolution.

VonEssen (*4*) did considerable work on the galvanic action in a digester which was reported in his paper in 1950.

It is understood that one investigator is continuing experiments to determine the effect of galvanic action on corrosion. Undoubtedly further information will be forthcoming in the near future.

CONCLUSIONS

While several digester corrosion causes have been determined and means of preventing corrosion in some cases have been outlined, there is still much work to be done in determining the effect of chemical changes in cooking liquors and other phases of digester operation that affect corrosion. Concentration of effort on chemistry of cooking liquors and galvanic effects appear to be in order for future studies.

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A Laboratory Approach to the Study of Digester Corrosion

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The corrosion experiments were conducted in glassware and in laboratory steel digesters. Weight losses of firebox steel immersed in cooking liquors provide the basic data which are supplemented by electro-chemical measurements. The reproducibility of the experimental data is often far from satisfactory. Some experiments had to be repeated scores of times in order to have a statistical basis on which to form conclusions. These conclusions strongly indicate that digester corrosion can be minimized by providing suitable operating conditions. Some conditions make the surface of steel more resistant to corrosion in alkaline liquors containing sulphidity. Such a surface state is called inert* as distinguished from a more active surface that corrodes readily. Corrosive attack is minimized by establishing an inert surface on steel and then providing conditions that keep it inert. Unfortunately an inert surface is very easily converted to an active form. Thus, traces of nascent hydrogen released in the corrosion reaction can catalyze this conversion. Polysulphides are one of the most dependable agents for stabilizing a surface. Corrosion is negligible when polysulphides constitute the major portion of the sulphidity. Small concentrations are less effective and in some cases can even be detrimental. White kraft liquors are very corrosive but this corrosion is greatly reduced when wood chips are present. Several factors contribute to the reduced corrosion: (1) the reaction with wood depletes the concentration of active chemicals, (2) when direct steam heat is used the condensate dilutes the chemical concentration, (3) black liquor constituents aid in stabilizing an inert steel surface. If full advantage can be taken of these factors, and if the laboratory digester surface is in an inert state at the start of a cook—then the corrosion is usually less than 20 m.p.y. However, even though every "known" precaution is taken—occasional cooks will show a rate from 50 to 100 m.p.y.or more.

THE digesters at the Tyrone mill of the West Virginia Pulp & Paper Co. had been in operation from 1924 to 1952 without evidence of serious corrosion. During that period, the sulphidity (3 to 8%) in the cooking liquor had been supplied by dissolving sulphur in caustic soda liquor. In January, 1952, the source of the sulphidity was changed to a by-product sodium sulphide (Na_2S) and by the end of that year it became evident that corrosion was then occurring at an excessive rate. This situation became the subject of an immediate investigation and since a change in the source of the sulphidity appeared to be the probable cause, attention was focused on this aspect. It was decided to conduct tests using small replicas of the mill digesters, but while these were being fabricated, preliminary studies were conducted using firebox steel test strips (Table I) immersed in boiling cooking liquors at atmospheric pressure using all glass equipment (Fig. 1).

Definite visible differences were apparent between the behavior in cooking liquors containing by-product sodium sulphide versus those prepared with elemental sulphur dissolved in caustic. The latter liquor caused no visible change in the test strips which at the end of the test period could not be distinguished from the original polished steel. With the by-product sulphide liquors, several minutes usually elapsed before any evidence of corrosion appeared. Then a localized brown or grayish spot appeared on a portion of the test strips and rapidly spread over the entire surface. Streaks of brownish precipitate sometimes formed in the liquor surrounding the strips. At the end of the immersion period, the strips had a dark coating which in some cases adhered firmly and in other cases was attached loosely to the steel. These visible differences in behavior in the various cooking liquors are reflected in weight loss measurements (Table II).

In the by-product sulphide liquor the weight losses show considerable variation depending on various factors including agitation, temperature, time of immersion, per cent sulphidity, and on whether the strips were scoured between immersions; but in all cases the weight loss is large. In contrast, corrosion is always small when the sulphidity is furnished by dissolving sulphur in caustic soda.

We next sought to find why cooking liquors prepared with by-product sodium sulphide are more corrosive. One of the possibilities considered was that corrosive impurities are present in by-product sodium sulphide, but this substance was found to be relatively free of impurities. Moreover, cooking liquors prepared with C.P. sodium sulphide were equally corrosive (Table II). All this seemed to rule out impurities as a cause of corrosiveness and led to the thought that cooking liquors prepared with elemental sulphur may contain substances that inhibit corrosion. Other ingredients normally present in elemental sulphur cooking liquors include sulphites, sulphates, thiosulphates (*4, 6*). Various concentrations of these salts were added to by-product sodium sulphide liquors and the corrosion studies were then repeated (Table III). Some of these salts appear slightly beneficial and others detrimental, but the large deviations between check runs made it difficult to assess the exact effect. However, it is quite clear that none of these salts provides a reduction in corrosion that approaches that accomplished by dissolving sulphur in caustic.

We then considered the possibility that the state of combined sulphur could be responsible for it is known that elemental sulphur cooking liquors contain polysulphides (Na_2S_n) whereas, the sulphur in by-product sodium sulphide is present entirely as monosulphide (Na_2S). To explore this aspect, a study was made of polysulphides prepared by other methods. Polysulphide formed by dissolving sulphur in a sodium mono-

* Passive would be a more descriptive term—but inert is used here because of a definite relation to liquors containing sulphidity.

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Table I. Analysis of Steels Used in Corrosion Test, as Furnished by Manufacturer

	Firebox steel	*Razor blade*
Carbon	0.15%	1.25%
Manganese	0.36	0.35
Phosphorus	0.014	0.010
Sulphur	0.032	0.010
Silicon	...	0.20
Chromium	...	0.20

All data in this paper are based on tests with firebox steel. In general, the behavior of razor blade steel was similar to that of firebox steel when tested under parallel conditions.

sulphide solution was added to caustic liquor.* The resulting cooking liquor was noncorrosive.† This supports the view that polysulphides (regardless of how prepared) inhibit corrosion, but to check this conclusion further, another approach was made. A non-corrosive cooking liquor containing polysulphide was heated under pressure to convert the polysulphide to sodium monosulphide and thiosulphate. The resulting liquor was found to be very corrosive, thereby providing additional evidence of the inhibiting action of polysulphide. Still further confirmation is provided by the fact that corrosion in the Tyrone mill digesters has been almost nil since returning to the use of polysulphide.

During this work we were continually confronted with the difficulty of securing reproducible results. Experience has provided a better understanding of some causes of deviation and has enabled us to take various precautions in conducting experiments. As a result, the agreement between check tests has improved but even so the deviations are often so large as to require some experiments to be repeated many times to provide an acceptable interpretation. After the investigation had been underway for some time we stumbled on the fact that some test strips resisted corrosion better than others. The test strips were prepared by being dipped momentarily in dilute acetic acid and then dilute sodium hydroxide. They were then scrubbed with Bon Ami, washed first with water, then with acetone, and dried in a desiccator. Finally it became apparent that the duration of the last step is an important factor, e.g., strips that are aged for a day often resist corrosion better than those used within an hour.

For convenience in the subsequent discussion, a steel surface that resists corrosion will be termed *inert* as distinguished from an *active* surface that corrodes more

* In most of the work described in this paper the term polysulphide represents liquors in which sufficient sulphur is present to provide the equivalent of sodium disulphide (Na_2S_2) and this formula will be used to express the polysulphide component of cooking liquor.

† Actually the corrosion ranged from 0 to 20 m.p.y. but to simplify the presentation such low rates will be referred to as noncorroding in this paper.

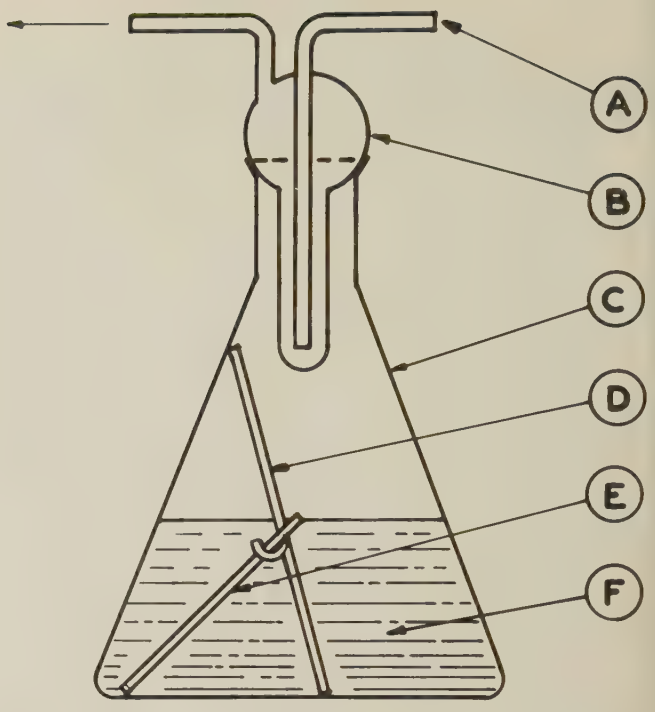

Fig. 1. Apparatus for glassware tests

A, cooling water inlet; B, finger condenser; C, flask; D, glass rod support for test strip; E, steel test strip; F, cooking liquor.

readily. The distinction is relative for there are all degrees of activity, ranging from very inert to very active. Moreover, the distinction becomes apparent only under certain conditions. In some systems active surfaces behave the same as the inert surfaces;* thus, neither surface corrodes in straight caustic soda liquors.†

A difference in behavior is usually found in caustic liquors containing sulphidity; the extent and often the nature of the effect depending on the form of the sulphidity. When the sulphidity consists entirely of sodium monosulphide (Na_2S) an active surface starts to corrode a few minutes sooner than an inert surface, and during the first 5 min. of immersion an inert surface shows less weight loss than an active surface. With longer periods of immersion both types of surfaces show approximately the same loss (Table IV). From this we infer that an inert surface becomes active during the initial period of immersion in this liquor, after which the corrosion proceeds at the same rate regardless as to whether the surface was initially inert or active.

* Because of these characteristics we have adopted the term *inert* instead of the more familiar *passive*—the term *passive* has acquired certain connotations that do not apply to the kind of surface that we term *inert*.

† More accurately, the corrosion rate is between 0 and 20 m.p.y.

Table II. Corrosion of Firebox Steel Test Strips Immersed 1 Hr. at 95 to 105°C. in White Cooking Liquors Containing Different Sources of Sulphidity

(Tests conducted in equipment shown in Fig. 1)

Composition of cooking liquor			*No. of[b] tests*	*Corrosion rate, m.p.y.[c]*		
NaOH[a] g./l.	*Sulphidity, %*	*Source of sulphidity*		*Average*	*Min.*	*Max.*
90	8	Bi-product Na_2S	10	110	80	140
95	8	CP Na_2S	5	100	90	130
95	8	Sulphur dissolved in caustic	10	10	0	20
115	28	Sulphur dissolved	10	10	0	20

[a] Expressed as Na_2O.

[b] Many more tests were run on each experiment than appear on the tables. Often each new experiment had to be repeated many times in order to find conditions that would give reasonable reproducibility. Therefore we have not attempted to include all data but instead have selected portions of the data obtained under those conditions that appear most reliable.

[c] In all tables corrosion rate is expressed to nearest 10 m.p.y. because basic data (weight loss per square inch) do not justify finer gradation.

Table III. Corrosion of Firebox Steel Test Strips in White Kraft Liquor[a] to which Various Salts Are Added

(Corrosion expressed as mils per year calculated from weight loss during an hour contact at 100 to 104°C. using glassware equipment shown in Fig. 1)

Salt added		Corrosion range of four tests, m.p.y.	
Formula	*G./l.*	*Min.*	*Max.*
None	...	90	130
$Na_2S_2O_3$	1	100	140
	2	110	150
	5	120	150
Na_2SO_4	1	100	110
	2	90	110
	5	110	140
Na_2SO_3	1	60	90
	2	80	100
	5	80	110

[a] Kraft liquor contained 115 g./l. active alkali (as Na_2O) and 28 g./l. Na_2S.

In liquors containing polysulphides there is a distinct difference between the behavior of active and inert surfaces, a difference that provides a convenient though arbitrary basis of classification. Inert surfaces remain bright and do not corrode in the presence of polysulphides, whereas, an active surface is immediately covered by a deep black film. This film is somewhat soluble in liquors containing polysulphides and such liquors tend to become very dark in color when in contact with an active surface.

When polysulphides furnish most of the sulphidity, an active surface usually becomes inert during the first cook, and the corrosion in subsequent cooks is negligible. Similar favorable results are often found with liquors containing mixtures of mono and polysulphides, but the results are less consistent, particularly when the monosulphide provides a larger part of the sulphidity. In such mixtures the duration and extent of the corrosive attack depends on mutual relations between the composition of the liquor and the activity of the steel surface. Each increase in the ratio of mono to disulphide necessitates a corresponding decrease in the activity of the surface if corrosion is to be prevented.

Thus an active surface will corrode in liquor B (Table V). After aging for a suitable period, the surface will no longer corrode in liquor B, but will retain enough activity to corrode in liquor C. However, extending the aging period will make the surface inert in liquor C.*

An experimental demonstration of the relation of surface activity to liquor composition presents difficulties because we have no present method of quantitatively measuring activity. Furthermore, uniform methods of preparing test strips will not necessarily give consistent results because there are variations in the rate at which a surface becomes deactivated through aging. Thus, if two steel strips are simultaneously dipped in acid, washed, and then aged for an hour; very often they will show a different degree of activity based on their behavior in liquors containing a mixture of mono and polysulphide. Even when the aging is prolonged sufficiently to provide a margin of safety, occasional cooks will show high corrosion as is illustrated in Table VI. Here the majority of the cooks had negligible corrosion, but when a bad cook did occur, the corrosion was very severe. All of which brings out that we do not yet know all the factors that contribute to the activity of a surface.

It was felt desirable to investigate whether the behavior observed with polysulphide is peculiar for that chemical, or might involve general principles that could be applied to other agents. To this end, an effort was made to interpret the behavior in the light of fundamental principles of corrosion chemistry.

Corrosion involves two primary reactions:

$$Fe^0 = Fe^{++} + 2e \qquad (1)$$

$$2H^+ + 2e = 2H^0 \qquad (2)$$

Expressed in words, iron atoms lose electrons and go into solution as ions, and the electrons are taken up by hydrogen ions to become hydrogen atoms. Unless other changes occur, e.g., oxidation, the hydrogen atoms eventually combine to form hydrogen molecules which are liberated as gas bubbles. Oxygen when present reacts with the hydrogen atoms to form water, and this reaction usually increases the corrosion rate.

By suitable experimental methods the chemical energy involved in the corrosion reaction can be con-

* It should be mentioned that the influence of a polysulphide is not shown unless it is at or above a certain level. Thus, the corrosive behavior of liquor D was similar to liquor E in which the sulphidity consisted entirely of monosulphide.

Table IV. Influence of Time on Corrosion of Inert and Active Firebox Steel Surfaces Immersed in White Kraft Liquor[a] at 100 to 104°C. Using Equipment Shown in Fig. 1

(Losses represent an average of four tests)

	Weight loss, mg./sq. in.		Corrosion rate, m.p.y.[b]	
Type of surface	*10 Min. contact*	*1 Hr. contact*	*10 Min. contact*	*1 Hr. contact*
Inert	0.1	1.5	40	100
Active	0.8	1.8	320	120

[a] Kraft liquor contained 118 g./l. active alkali (as Na_2O) and 28 g./l. Na_2S.

[b] With a surface that is initially active, or becomes active, the corrosion rate quickly reaches a maximum and then decreases because of partial protection provided by the corrosion film that is formed.

Table V. Composition of Sulphidity Liquors Used in Study of Influence of Different Ratios of Mono and Disulphide.

Code	*Active alkali, g./l.*[a]	*Monosulphide, g./l.*[a]	*Disulphide g./l.*[a]
A	115	0	28
B	115	14	14
C	115	21	7
D	115	27	1
E	115	28	0

[a] Expressed as Na_2O.

Table VI. Corrosion of Firebox Steel Strips in Successive 30 Min. Immersions at 100 to 104° C. in Liquor C, Table V

(Test strips were cleaned after each immersion and then allowed to age 1 hr. in air before next immersion in fresh liquor. Test conducted in equipment shown in Fig. 1)

	Corrosion rate, m.p.y.		
Order of cook	*Test strip A*	*Test strip B*	*Test strip C*
1	10	250	10
2	0	10	20
3	0	20	20
4	20	0	0
5	10	0	20
6	20	20	500
7	10	10	200
8	20	20	20
9	20	0	20
10	0	20	300

Table VII. Oxidation Potential of Firebox Steel with Inert Surfaces in Cooking Liquors

NaOH As Na_2O, g/l.	*Sulphidity source*	*Millivolts[a] at 25°C.*
115	28% Sodium monosulphide	480–540
115	28% Sodium disulphide	500–510

[a] Range as measured against calomel electrode but corrected to hydrogen potential = 0.

verted into an electrical form that can be measured.* The force driving iron atoms into a solution is known as the oxidation potential. A study reveals that the oxidation potential of inert surfaces is approximately the same whether the sulphidity of a cooking liquor is furnished by mono or polysulphide (Table VII). From this we could expect similar corrosion rates, whereas, weight loss data consistently show less corrosion of inert surfaces in polysulphide liquors.

This seeming contradiction led to a further consideration of the corrosion reaction. In the equation for that reaction, $Fe^0 + 2H^+ = Fe^{++} + 2H^0$, it is implicit that iron atoms will continue to go into solution only as long as an equivalent quantity of hydrogen ions can escape from the system. This brings us to the well-known fact that hydrogen escapes more readily from some systems than others. Consider zinc. A strip of pure zinc does not readily dissolve in sulphuric acid solution because hydrogen is reluctant to be liberated from a pure zinc surface, or as commonly expressed, the overvoltage is high on a zinc surface. However, when a platinized-platinum strip is inserted into the solution and short circuited to the zinc, a current will be registered; the zinc dissolves rapidly and hydrogen bubbles are liberated. However, the hydrogen is liberated not at the zinc, but instead at the platinum electrode where the hydrogen overvoltage is low. A high overvoltage can also be overcome by admitting oxygen to the system to react with hydrogen to form water. This accomplishes the removal of hydrogen and accelerates the corrosion. Agents, such as oxygen, which will do this are called depolarizers.

Since the rate of corrosion is influenced by the ease with which hydrogen escapes from the system, this suggested a possible reason for the beneficial effect of polysulphides, namely that they might hinder the escape of hydrogen. The existence of such an influence can be evaluated by overvoltage studies and such studies were made using steel strips immersed in the various cooking liquors. It came as a surprise to find that hydrogen overvoltage is less in a liquor containing polysulphide than one with monosulphide. In other words, the polysulphide apparently depolarizes atomic hydrogen, a conclusion supported by other studies.** In view of the usual influence of depolarizers such as oxygen we would expect that corrosion would be accelerated by polysulphide. This posed a dilemma since fundamental chemistry appeared to cast doubt on the protective value of polysulphides, whereas weight loss data repeatedly demonstrate their value, particularly when they furnish most of the sulphidity.

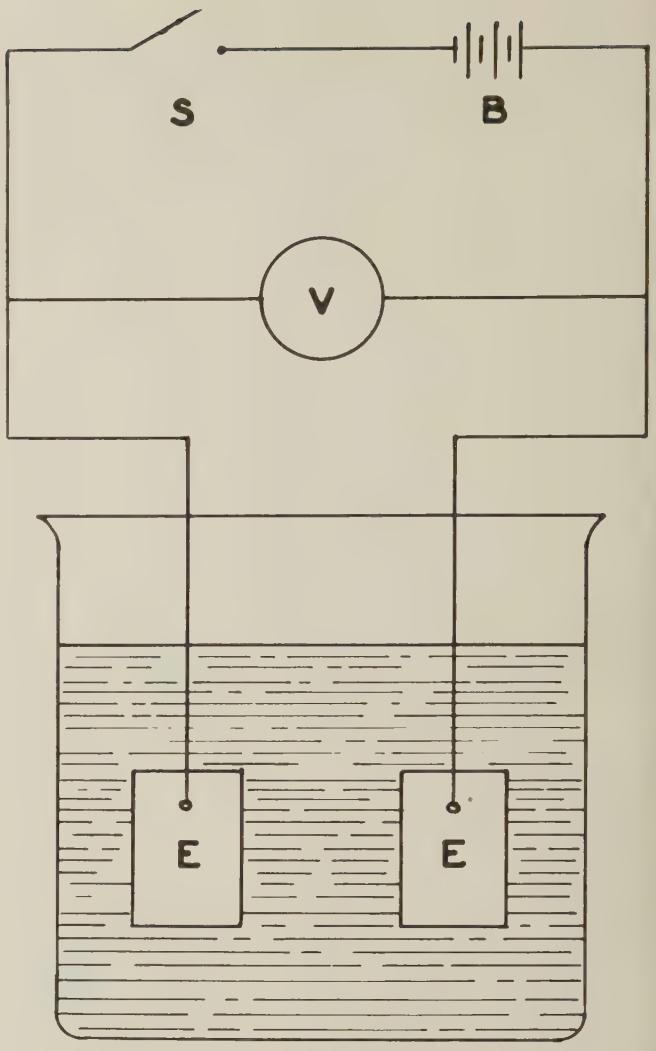

Fig. 2

B, external e.m.f.; E & E steel electrodes; S, switch; V, voltmeter.

This led to a re-examination of the chemical principles involved. First of all, oxidation potentials tell us that, theoretically, steel immersed in either kraft or polysulphide cooking liquor will corrode completely if given time, but potentials do not say how rapidly any reaction will proceed. Some reactions proceed so fast that the rate cannot be measured; whereas, other reactions with a greater driving force may go at such a slow rate that no change is observed. We might use an analogy of an automobile that is to go from one city to another and has plenty of gas and power to do so, but it cannot go from one city to another unless there is a suitable path over which to move. If the path is in bad shape the car will move slowly. On a good road it will move faster, and on a turnpike it can go at high speeds. In a chemical reaction a catalyst often provides a path on which a reaction moves. All this suggested that the distinction between active and inert surfaces might involve the presence of a catalyst, so a further study was made of conditions that favor the formation of active and inert surfaces.

It was found that steel acquires an active surface by being: (1) immersed in an acid (*1*), (2) immersed for several minutes in a kraft liquor, (3) made the cathode

* Such methods are described in standard physical chemistry texts; therefore, the detailed procedures will not be given here.

** To give one other illustration, an external e.m.f. was applied to the cell shown in Fig. 2. When the external e.m.f. was removed, the cell showed a back e.m.f., the magnitude depending on the composition of the liquor in the cell. The back e.m.f. was less with Na_2S_2 than for Na_2S, indicating that the disulphide liquor is able to depolarize more of the hydrogen formed by the external e.m.f.

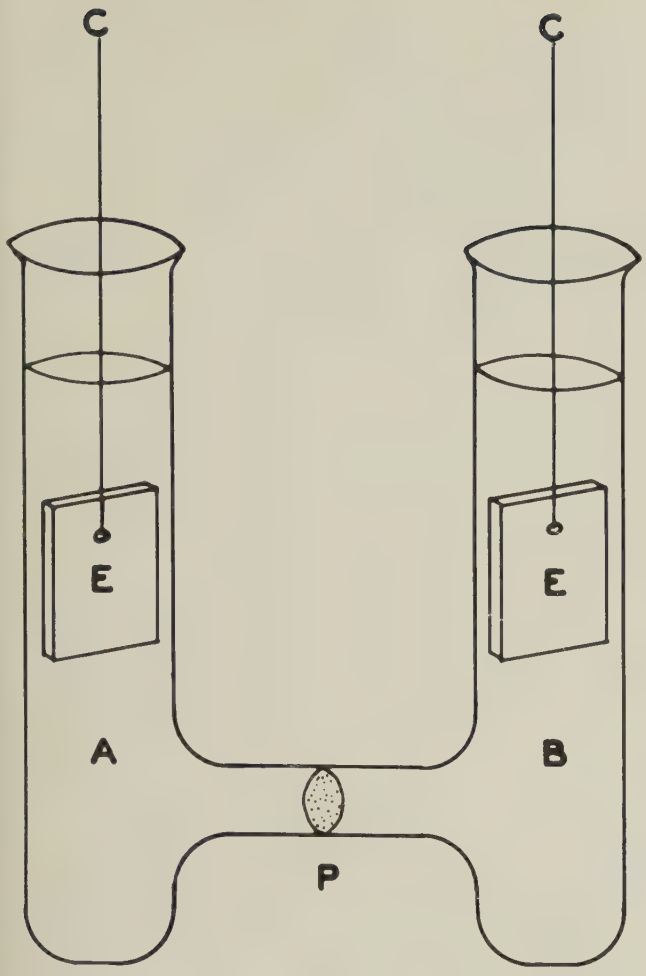

Fig. 3

C, connections to ammeter; E, steel strips; P, porous plug; A, kraft liquor; B, polysulphide liquor.

in an alkaline cell to which an external e.m.f. is applied.

The activity of steel strips is lost to a greater or lesser extent by being (4) aged in air, (5) immersed in boiling water, (6) made the anode of an alkaline cell to which an external e.m.f. is applied, (7) immersed in a polysulphide solution.

The formation of an active surface in all these cases is accompanied by the liberation of nascent hydrogen. If and when the hydrogen is dissipated, the surface becomes progressively less active. After the complete dissipation of hydrogen, a protective layer often forms on the surface which thereby becomes still more inert. The existence of protective layer is indicated by the fact that abrasion will make an inert surface less resistant to corrosion in sulphidity liquors. Presumably surfaces that age in air become covered with an oxide film so often associated with a passive state. The protection provided by dipping steel in polysulphide is probably due to a depolarizing action of the film remaining on the surface. This behavior will be discussed later.

And so—we come to a probable basic difference between active and inert surfaces; namely, an active surface is a steel surface on which a catalyst (in this case nascent hydrogen) accelerates the corrosion in sulphidity liquors. Conversely, an inert surface is without such a catalyst, and in addition, may have a protective film.

However, even though we start with an inert surface, i.e., one that is less susceptible to corrosion, this is not enough to prevent rapid corrosion from developing. The fundamental corrosion reaction tells us that nascent hydrogen is liberated by the corrosion reaction itself; consequently, although a surface may be initially free of hydrogen and resist corrosion—even so, it will corrode to some extent when immersed in a cooking liquor. Unless the hydrogen simultaneously liberated is dissipated as it forms, it will eventually convert an inert surface into an active one.

We can now begin to understand why polysulphides are useful. Steel remains in a noncorroding state when immersed in a polysulphide liquor because the hydrogen is depolarized as fast as it forms and before it can damage a surface. This is illustrated by an experiment.

White kraft liquor was placed in leg A of an electrolysis cell and white liquor containing polysulphide in leg B (Fig. 3). A porous glass membrane in the center of a horizontal arm allows an electric current to flow but prevents the liquid phases from diffusing from one leg to another. A steel strip with an inert surface was inserted into each limb. Corrosion occurred in the kraft liquor (A) but not in the polysulphide (B) (Table VIII). The experiment was then repeated using fresh liquor and fresh test strips, but this time the strips were connected through an ammeter which registered a small current 0.1 to 0.2 ma.*; after 15 min. immersion the strips were bright and neither suffered any appreciable weight loss (Table VIII). This favorable behavior is caused by the fact that all hydrogen formed in the entire system is liberated at the polysulphide electrode where it is depolarized before it can do any harm. Consequently, the polysulphide keeps both steel strips in an inert state, and corrosion is prevented even on the strip in the corrosive kraft liquor. The experiment was again repeated, but this time a steel strip with an active surface was placed in the kraft liquor section of the elec-

* The strip in the polysulphide liquor in limb B was cathodic.

Table VIII. Representative Data for Experiments Conducted in Equipment Shown in Fig. 3

(Each test conducted for 15 min. at 90°C.)

Limb A			*Limb B*			
Source sulphidity in liquor[a]	*Initial condition steel surface*	*Weight loss, mg./sq. in.*	*Source sulphidity in liquor*[a]	*Initial condition steel surface*	*Weight loss, mg./sq. in.*	*Current, ma.*
Mono Sulphide	Inert	0.6	Disulphide	Inert	0.1	...[b]
Mono Sulphide	Inert	0.2	Disulphide	Inert	0.2	0.1 to 0.2
Mono Sulphide	Inert	0.3	Disulphide	Inert	0.1	0.1 to 0.2
Mono Sulphide	Active	1.2	Disulphide	Inert	0.2	2.0 to 3.0
Mono Sulphide	Active	1.0	Disulphide	Inert	0.4	2.0 to 3.0

[a] Cooking liquor contained 115 g./l. active alkali as Na_2O and 28% sulphidity.
[b] Steel strips not connected.
Electrode in limb B was cathodic and electrode in limb A was anodic.

trolysis tube. The ammeter registered a higher current (2.0 to 3.0 ma.) and the steel strip in the kraft leg became covered with a black film and lost approximately the same weight that normally occurs in a kraft liquor. Evidently, an active steel strip corrodes more rapidly than the liberated hydrogen can be depolarized at the polysulphide electrode. Consequently, the strip in the kraft liquor leg remains active and corrodes.

In the experiments just described the depolarizing influence of the polysulphide is exerted at a distance. The influence is more powerful when a steel surface is in direct contact with the polysulphide liquor. Then even an active surface usually becomes inert and corrosion stops, particularly when polysulphides constitute a major portion of the sulphidity. The results are less consistent when polysulphides furnish only a portion of the sulphidity, then they may still prevent corrosion from starting on an inert surface but may not be able to change an active surface into an inert state. In that event the unfavorable aspects of a depolarizer predominate, and the corrosion may be much greater than in the complete absence of a polysulphide.

The corrosion products are soluble in polysulphides liquors, and this factor may influence the duration of the corrosive attack. When the polysulphide concentration is high (liquor A, Table V), the black film on an active surface dissolves as it forms and the surface becomes inert. Weaker concentrations of polysulphides (liquors B and C, Table V) may completely dissolve the black film from a surface that is mildly active but not from one that is very active. In the latter case, a relatively thick layer of corrosion product accumulates on the surface which remains active, and the corrosion may exceed 300 m.p.y.

Up to this point, the discussion has dealt with data developed in glassware using white liquors without wood chips. Most of the subsequent discussion deals with experimental studies in miniature digesters (Fig. 4). No balance available had sufficient capacity to weigh a lab digester with the necessary sensitivity to measure the weight loss. Therefore, the use of steel strips for measuring corrosion was continued. From four to six strips were used in each cook—some were inserted so as to have metal to metal contact with the digester shell. Such contact was provided by resting the strips on the bottom of the digester or by suspending them with a steel wire (Fig. 5). Other strips were suspended using a fiber glass cord so as to be insulated from metallic contact with the shell.

Difficulties arose in selecting a suitable heating procedure. In the initial runs, steam was introduced into the digester at the start of the cook, but this gave excessive dilution. Indirect heat was then used but resulted in concentration. Finally, a compromise procedure was employed. Indirect heat was applied to bring the digester to a boiling temperature after which steam was introduced at pressures from 125 to 175 p.s.i. The resulting dilution corresponded to that found in the pulp mill digesters.

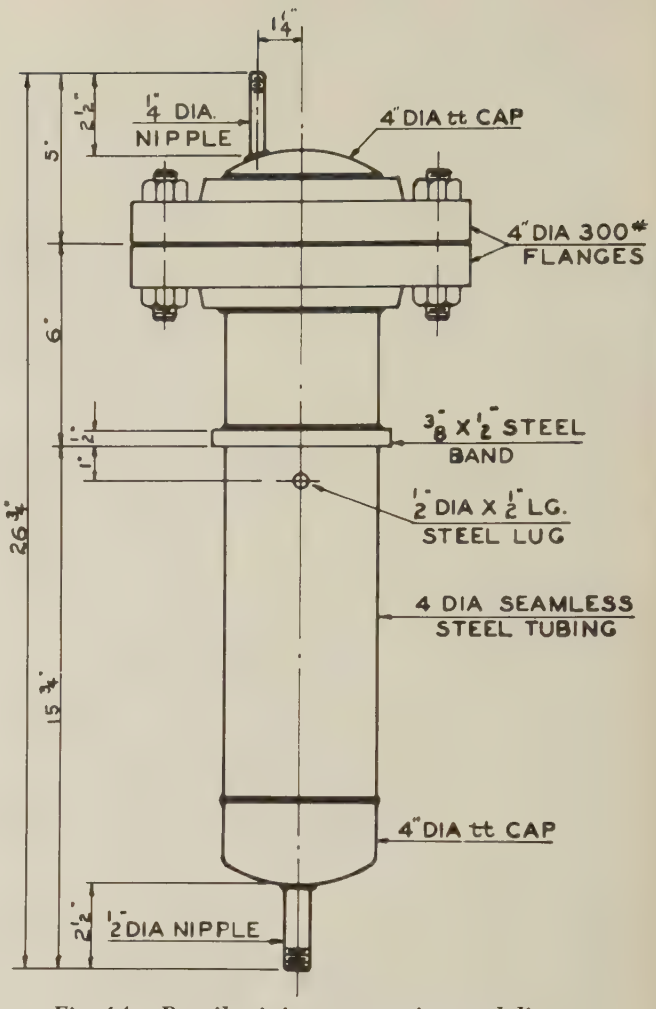

Fig. 4A. Detail miniature experimental digester

When the sulphidity of the cooking liquor consisted mainly of polysulphides, the experience was the same as in all previous studies.* The corrosion was negligible (Table IX) and the steel surface remained bright. It is reported that when polysulphides are used in mill digesters the shell becomes coated with a firm coating of calcium carbonate.**

* Work is now underway to determine the minimum ratio of Na_2S_2 to Na_2S that will consistently reduce the corrosion to a low level in the lab digesters.
** Personal communication from L. Dela Grange, West Virginia Pulp & Paper Co.

Table IX. Corrosion of Firebox Steel Test Strips in a Typical Series of Tests Conducted in Laboratory Digesters

Test series	Liquor composition: Active alkali, g./l. as Na_2O	Liquor composition: Sulphidity %	Liquor composition: Sulphidity Source	Wood chips	Classification of corrosion loss expressed as percentage of number of cooks within indicated bracket: 0–10	11–20	21–50	51–100	Over 100
1	95	8	Na_2S	Mixed hardwood, oak	40	19	6	8	27
2	95	8	Na_2S	Mixed hardwood, oak	50	22	6	6	16
3	95	8	Na_2S_2	Mixed hardwood, oak	75	24	1	0	0
4	115	28	Na_2S	Pine	50	34	4	10	2
5	115	28	Na_2S_2	Pine	75	20	5	0	0

Cook conducted at 125 p.s.i. pressure for 1 hr., using 2 l. cooking liquor and 350 g. wood chips. Since most of corrosion occurs within first hour, the corrosion rate as shown is higher than if test had been conducted for the full cooking time. Runs 1 and 2 are given to illustrate variation between different runs conducted under similar conditions.

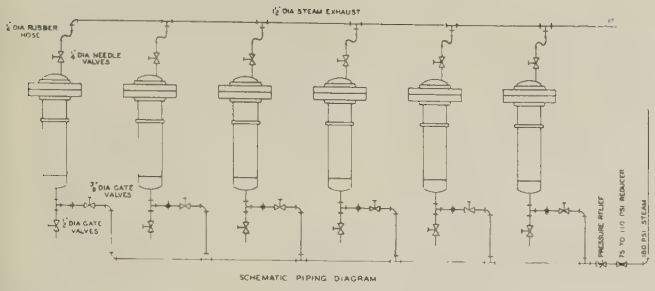

Fig. 4B. Battery of laboratory experimental digesters

With liquors in which monosulphide furnished the sulphidity, the use of wood chips made a distinct change in the corrosion pattern. When a new digester was placed in service, the corrosion was high in the initial cooks. After that, the corrosion frequently was much less than when using white liquor without chips—in fact, numerous cooks gave losses as low as with polysulphides; i.e., less than 20 m.p.y. However, to offset such favorable results, many cooks gave corrosion over 100 m.p.y., and in some cases over 400 m.p.y. The extent of corrosion was often influenced by the manner in which the test strips were placed in digesters; e.g., instances of low corrosion were more numerous with test strips that had metal to metal contact with the digester shell, than with test strips suspended by a fiber glass cord and therefore insulated from the shell.

A glassware study was made of the corrosiveness of liquor samples taken from a kraft digester cook (Table X). With all liquors taken after the cooking started, an inert surface does not corrode, or more accurately, the weight loss is negligible. In contrast, an active steel surface shows greater corrosion in the liquor taken shortly after the cook had started than in the original white liquor. Samples of cooking liquor taken later during the cook are noncorrosive even to an active steel strip which presumably is converted to an inert state. The decrease in corrosiveness is partly due to depletion of active alkali by the cooking reaction with wood and partly to the dilution by steam condensate.* However, this is not the full explanation because the decrease in corrosion is greater than when corresponding dilutions of white liquor are made with water. Moreover, dilution certainly does not explain why the rate of corrosion on an active surface should increase during the period immediately following the start of a cook. Neither does dilution explain those instances in which the weight loss during a cook is greater than that caused by undiluted white liquor without chips.

The over-all behavior is reminiscent of that previously reported for polysulphides and suggests that the constituents of black liquor act as a depolarizing agent. Consequently experiments that had been empolyed to study the behavior of polysulphide were repeated with the black liquor. The resulting data support the view that black liquor acts as a depolarizer although possibly not quite as effectively as polysulphide. Therefore, the principles that have been developed for the influence of polysulphide on corrosion should apply for the black liquor constituents. Before showing the application to a cooking liquor containing black liquor, let us restate these principles.

The process of corrosion produces its own catalyst (nascent hydrogen) to accelerate corrosion in suphidity liquors. If the corrosion rate is slow, a weak depolarizer may be able to remove the hydrogen as fast as it forms, and so, keep the surface inert. However, when corrosion is rapid, a stronger depolarizer is needed because a weak depolarizer only partially removes the hydrogen produced during corrosion. Any hydrogen not removed makes the surface active and then a depolarizer becomes detrimental.

Thus, we have a paradox that a depolarizer increases corrosion under some conditions and decreases it under other conditions. Based on general experience we could expect a depolarizer to increase corrosion by making it easier for the reaction to proceed. But, with a sulphidity liquor such influence can be more than overbalanced when the depolarizer is sufficiently powerful to keep the surface in an inert condition.

* In the laboratory digester studies using indirect heat and in which dilution from condensation does not occur, the corrosiveness of the liquor diminishes at a slower rate than when steam was admitted in the digester.

Table X. Corrosion of Firebox Steel Strips when Cooked 1 Hr. in Samples of Cooking Liquor Taken at Intervals from a Kraft Digester Cook

(Tests conducted in equipment shown in Fig. 1)

Liquor sample number	*Interval of time between start of cook and sample, min.*	*Active alkali as Na_2O, g./l.*	*Corrosion, m.p.y. Active surface*	*Corrosion, m.p.y. Inert surface*
1	0	80	80	
2	10	50	200	10
3	30	35	50	10
4	60	30	20	10
5	90	..	10	0
6	120	..	0	0

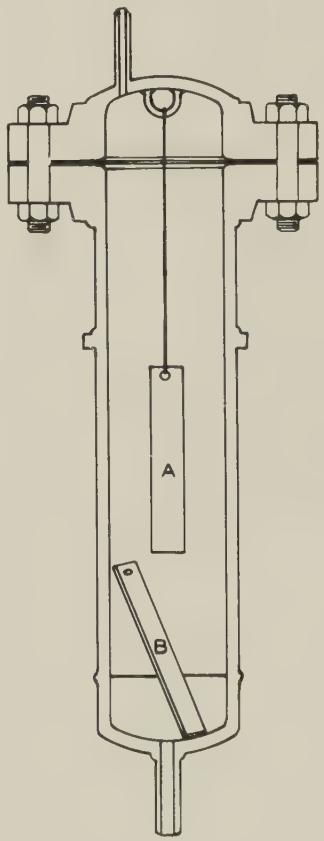

Fig. 5. Positions of steel test strips in laboratory digester

A, suspended strip; B, strip in direct contact with digester shell.

Since this paradox is not easy to grasp at first reading, let us restate it in other terms. Iron immersed in sulphidity liquor can have a dual personality. In one form it behaves like a noble metal and does not corrode appreciably. It remains noble as long as any hydrogen is removed as fast as it forms. But if the corrosion rate exceeds the capacity of the depolarizer, then the hydrogen is only partially removed and the iron surface becomes active. That is, it behaves like a base metal and then the detrimental effect of a depolarizer predominates and still further accelerates the corrosion.*

We can now consider the changes taking place during a kraft digester cook in which the sulphidity is furnished by sodium monosulphide. If we start with white liquor, such a liquor is very corrosive, and no depolarizer is present. After the cooking starts, the corrosiveness gradually diminishes due to depletion of active chemicals by the reaction with wood and to dilution by condensate when direct steam heat is used. There is a corresponding increase in the relative concentration of black liquor constituents which act as a depolarizer. The interplay of these two factors: (1) decreased corrosiveness of the liquor, and (2) increased concentration of the depolarizer is illustrated in a study of the corrosion of active and inert surfaces in liquors taken at intervals from kraft digester cook (Table X).

In the starting white liquor, an inert surface will take longer before corrosion starts, but once it does start the surface has become active; and then corrosion occurs at the same rate as on the surface that was active from the start. However, corrosion of inert surfaces can be retarded by starting the cooking rapidly so as to form some black liquor, and this removes the small amount of hydrogen which forms on an inert surface. Consequently, the surface remains inert and the over-all loss should be less than 20 m.p.y.

Next consider an active surface. This starts to corrode immediately when immersed in the white liquor and the corrosion continues during the initial cooking stage while the liquor is still very corrosive. Nascent hydrogen forms rapidly on an active surface, and is only partially removed by the small amount of the black liquor present at this stage. Consequently the detrimental effect of a depolarizer predominates: the corrosion rate jumps to 200 m.p.y. or more. As the cook proceeds, the corrosiveness of the liquor diminishes further; consequently less hydrogen is liberated and more black liquor is present to depolarize it. Finally a stage is reached when the hydrogen is removed faster than it forms; then the surface becomes inert.

Consequently, at the end of a cook the digester surface is in an inert state and under favorable conditions should remain inert. Therefore, the corrosion should be small in the succeeding cook. If, instead, the corrosion is high it indicates that the surface has become active. Since, when severe corrosion occurs, it takes place mainly during the initial stages of the cook, it follows that when unfavorable conditions develop they will be found at or near the start of the cook. We are probably far from knowing all conditions that can lead to unfavorable effects, but will mention those that have been encountered in our investigation with lab digesters:

1. The woods used in this investigation were pine and a mixture of oak and hardwood. With both types, the corrosion ranged from less than 20 m.p.y. in many cooks to over 100 m.p.y. in other cooks. Instances of severe corrosion appeared to be somewhat more frequent with oak and hardwood than with pine, but the evidence is not definite. However, based on over-all experience it would seem that when all operating conditions are *right*, the corrosion will be low regardless of the type of wood used; but when conditions are less favorable, then oak and hardwood can more often push the system into a corroding state.

2. Other workers (*2*) have described what has come to be known as hot plate boiling because of a similarity to the action when small quantities of water are dropped on a hot plate.

Hot plate boiling occurs when a film of cooking liquor is deposited on a hot steel surface and becomes concentrated by evaporation, the increased concentration of active chemicals causing severe attack. Hot plate boiling occurs during the filling stage on areas where splashing or foaming leaves films of liquor on uncooled surfaces. Hot plate boiling involves evaporation and consequently does not occur on surfaces submerged in liquor. Moreover, it does not occur on any surfaces after steam is admitted and causes dilution. However, surfaces that are attacked during the filling stage may remain active and be more susceptible to corrosion during the ensuing cook.

3. In studies using white liquor without chips, it was found that rust spots, deep scratches, or even drastic scouring reduces the resistance of a steel surface to corrosion in sulphidity liquors. The effect of these factors on corrosion in laboratory digester cooks is now being studied. Preliminary data indicate the effect is less detrimental in laboratory digester cooks than in white liquor without chips.

4. When white liquor is added before the chips and is in contact with the digester shell for an appreciable time (e.g., 20 to 30 min.) before cooking starts, sufficient corrosion can occur to make the surface active. In some cases this action may be retarded by mixing black liquor with the white liquor, and for this, certain ratios are more favorable than others—depending on the composition of each of the liquors. With the liquors used in this study, a mixture of approximately 20% black liquor and 80% white liquor was preferable to other ratios. However, this precaution only delays the onset of the corrosive attack and such a mixture should not be held too long in a digester before adding the chips and starting the cook.

In the laboratory digesters it was found beneficial to add chips before the liquor. However, it is recognized that this benefit may not be fully reflected in the mill digesters which retain more heat and therefore are at a higher temperature during the filling stage. This is mentioned because when dried chips become hot they can increase the corrosion rate. This was demonstrated in some experimental cooks in which the chips and steel strips in the digester were steamed to displace air prior to adding the cooking liquor (Table XI) (*4, 6*). In all such cases, the cook had a very high corrosion rate. Presumably, heat releases organic acids from the wood and these penetrate the thin alkaline film on the digester wall, making the surface active.

* Theoretically a depolarizer accelerates the corrosion of a noble metal, but the actual effect is negligible.

Table XI. Corrosion of Firebox Steel Test Strips in Laboratory Digesters in Typical Series of Tests
(Influence of presteaming chips in digester using chips "as is" and also chips that had been presoaked in 10% NaOH solution)

Wood species	Chips presoaked in 10% NaOH prior to being placed in digester	Steamed in digester prior to adding liquor	Number of cooks in run	Classification of corrosion, m.p.y. expressed as per cent — cooks within indicated bracket[a]				
				0–20	21–30	31–50	51–100	Over 100
Pine	No	No	32	72	15	9	0	3
	No	Yes	40	0	0	0	10	90
	Yes	Yes	40	90	5	0	5	0
Oak	No	No	12	50	16	0	16	16
	No	Yes	15	0	0	0	0	100
	Yes	Yes	40	75	20	0	2	2

Cooks conducted for 1 hr. at 125 p.s.i. steam pressure using 350 g. wood chips, 1.6 l. white kraft liquor plus 0.4 l. black liquor.
[a] Variations are found between different runs, therefore these results should be taken only as illustrating typical trends.

It was found that this cause of high corrosion rate usually could be eliminated by presoaking the chips in a 10% solution of sodium hydroxide.* Subsequent experience cooking chips precoated with alkali has been very favorable; particularly when 20 to 25% black liquor is mixed with the kraft cooking liquor.

5. Circulating streams of liquor can induce corrosion. The movement of liquor at high velocity through a pipe and the impingement of the liquor on a steel surface can establish damaging electropotentials. The principal danger from this is that the area on which the liquor impinges will become active and suffer greater corrosion during the ensuing cook.

Some of the aforementioned factors may activate limited areas within the digester and result in a localized attack that can be serious during the early stages of a cook. Thus, in the data of Table X, the corrosion of an active surface reached 200 m.p.y., as compared to 10 m.p.y. for an inert surface.

Severe attack may be confined to a limited area as is illustrated by the wide variations in weight loss that have been found in some of our experimental cooks. In some instances, one or two test strips would have an m.p.y. over 100, whereas other test strips in the same cook would have an m.p.y. below 20.

The area of attack may be increased or it may be reduced through influences provided by adjacent areas. The existence of reciprocal influences is shown in various ways. As mentioned previously, test strips insulated from the digester shell usually show a higher corrosion rate than those having metal to metal contact with the shell, a behavior similar to that covered by the data in Table VIII. This would suggest that the final stage of a cook stabilizes the digester surface so that in the next cook it provides an influence similar to that of electrode B in Fig. 3, Table VIII. As a result, any strip in contact with this stabilized surface tends to remain inert during the next cook.

However, reciprocal influences are not always beneficial. Very active areas may produce more hydrogen than can be depolarized, and this hydrogen may accumulate on adjacent cathodic areas causing them to become active. These, in turn, can activate still other areas, resulting in a chain reaction to extend the corrosive attack. This action is illustrated by experiments in which a portion of a lab digester was made very active. As previously mentioned, acid makes a surface active; and whenever a portion of a digester was swabbed with dilute acid, the corrosion was always severe in the following cook. Moreover, corrosion occurred not only on the strips placed in direct contact with the acid treated area, but also extended to the strips placed in remote portions of the digester. Thus, when a small area at the bottom of a laboratory digester was swabbed with dilute acid, corrosion occurred on test strips suspended by a steel wire from the cap of the digester (Fig. 5). Although such corrosive effects can extend through the entire laboratory digester, the actual distance involved is relatively small. We do not now know how far such attack could travel in a pulp mill digester.

SUMMARY

This investigation has covered many approaches during a period of 2 years in which over 5000 weight loss measurements were made. For this paper we have selected data on those factors which appear to us to have a major role on the corrosion of steel surfaces by sulphate liquors. Chief among these are the activity of the surface and the concentration of depolarizing agents in cooking liquors.

For convenience in the discussion, the term active is applied to surfaces readily susceptible to corrosion by sulphate liquors; whereas, the term inert describes surfaces that resist such corrosion. The distinction is relative for there are all degrees of activity reaching from very active to very inert; moreover, any marked difference in behavior is revealed only in certain liquors. Thus, in white kraft liquor containing monosulphide sulphidity, an active surface starts to corrode a few minutes sooner than an inert surface: after which both types of surface show similar high loss usually ranging from 80 to 160 m.p.y. Presumably this liquor quickly activates an inert surface.

In a liquor containing a high concentration of a depolarizer, an active surface has a high initial corrosion rate but later becomes inert, and the corrosion rate of an inert surface is less than 20 m.p.y. In this connection, the use of polysulphides (a strong depolarizer) to furnish the sulphidity provides a most dependable method of consistently controlling corrosion by sulphate liquors.

The greatest difference between inert and active surfaces is found in liquors containing moderate amounts of depolarizers. Consider a liquor taken from a digester shortly after the start of a cook (Table X) which contains sufficient black liquor to act as a moderate depolarizer. In this liquor an inert surface will have a loss of less than 20 m.p.y.; whereas an active surface may have a loss greater than 200 m.p.y. This brings

* Other concentrations of sodium hydroxide have not yet been studied. It should be mentioned that soaking chips in black liquor was helpful in some instances, but the beneficial effect was not as consistent as with the 10% NaOH solution.

out that the black liquor formed in the cooking process can be either a friend or foe in the struggle against digester corrosion, so it behooves us to learn how to use it as an ally. Basically this is a matter of providing operating conditions that retard the formation of nascent hydrogen.* Knowledge of this basic principle has helped to guide the search, but for the main part the discovery of specific favorable conditions has resulted from cut and try empirical experimental studies. By employing conditions found to be favorable we have been able to greatly increase the proportion of cooks with less than 20 m.p.y. and thereby reduce the average loss. However, even when every known precaution is taken, occasional cooks show a high corrosion rate. This may suggest that when cooking with liquors containing monosulphide sulphidity we are dealing with an equilibrium so precarious that the slightest deviation or departure from optimum conditions is sufficient to push the system into a corrosive state. Rather than accept this negative approach, it will be more constructive to assume that present difficulties are due to controllable factors that will be discovered by more intensive study.

* This does not exclude the possibility that other agents not yet identified may also be corrosion catalysts.

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This report is the product of many workers. Unfortunately space does not permit detailed mention of all those who participated—but I cannot conclude without expressing deep appreciation to Lynne Ferner. He initiated the program and has been a constant source of help and encouragement. Also, I wish to express thanks to Nicholas Shoumatoff, Charles McCarthy, and Lou Dela Grange for many constructive suggestions.

Determination of Aldehyde in Cellulose—A Review of Methods

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Some of the problems in the determination of aldehyde in cellulose are discussed. Various methods are critically reviewed in relation to the present knowledge of cellulose chemistry.

Various methods have been proposed for the estimation of aldehyde in cellulose, each having its advantages and limitations. The object of this paper is to review these methods in relation to what might be expected of them on the basis of our present knowledge of cellulose chemistry and to discuss some of the problems in the determination of aldehyde in cellulose.

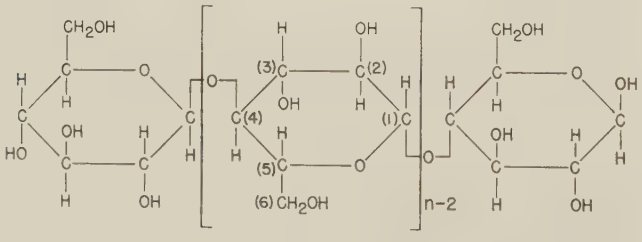

Fig. 1. Generally accepted formula of cellulose chain

The generally accepted formula of a cellulose chain is given in Fig. 1 for reference. It is possible for aldehyde groups to be formed at the 1, 2, 3, and 6 positions in the anhydroglucose ring. A reducing group is present on one end of each chain in the 1 position, presumably in the form of a hemi-acetal ring unless it is changed during isolation and purification of the cellulose. Otherwise, the 1 position is tied in the polymer chain. The hydrolysis of cellulose produces a terminal aldehyde group in the 1 position for each break of the chain.

As the chemistry of the modification of cellulose by various reagents is still somewhat obscure, except for a few special cases, the position of the aldehyde group in the anhydroglucose ring is usually open to question. The partial oxidation of the primary alcohol group produces an aldehyde in the 6 position, although no reagent is known which gives aldehyde in this position exclusively. The reaction of cellulose with chromium trioxide in acetic acid–acetic anhydride produces some aldehyde in the 6 position (*1*, p. 127). Oxidation with periodic acid produces the dialdehyde type of oxycellulose with aldehyde groups in the 2 and 3 positions.

An excellent review of the chemistry of modified cellulose has been given by Purves (*1*).

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PROBLEMS IN THE DETERMINATION OF ALDEHYDE IN CELLULOSE

pH and Temperature of the Medium

The pH of the reaction medium is not particularly critical and may vary over a wide range for unmodified cellulose where all aldehyde is in the 1 position. It is necessary that the acidity and temperature be low enough to prevent hydrolysis from occurring at a measurable rate. The kinetics of the hydrolysis of cellulose has been studied over a wide range of conditions, but apparently little has been done in the very low acidity range. Staudinger and Sorkin (*2*) showed that normal acetic acid at 53°C. (pH about 2.4) did not cause an appreciable change in the D.P. of raw cotton in 24 hr., but that a definite change occurred in 120

hr. Normal solutions of boric acid (pH about 3.4) and of sodium bisulphite (pH about 4.2) caused no measurable change in D.P. in 120 hr., but some change occurred in 1226 hr. A reaction medium for the determination of aldehyde in unmodified cellulose could, therefore, have a pH as low as 2.5 at room temperature during a limited period without appreciably degrading the cellulose.

The acetal linkages in unmodified cellulose are very stable in alkali. Goldfinger and Mark (*3*) observed no change in the specific viscosity of cotton linters soaked in 17.5% NaOH at 20°C. for 168 hr. Several dissolving pulps derived from wood showed considerable change in specific viscosity. This was ascribed to degradation during pulping and bleaching.

Oxygen in the presence of alkali has a degrading effect on cellulose, and this reaction is used by the viscose industry as a means of obtaining controlled depolymerization. Certain heavy metals have a catalytic effect on this reaction (*4*, *5*). The degradation is not as extensive if the alkali cellulose is covered with sodium hydroxide solution (*6*, p. 127). The alpha-cellulose content of an alkali cellulose derived from cotton decreased from 82.5 to 78.6 when steeped in about 18% NaOH for 30 days.

Although considerable data are available on the effect of alkaline solutions in the low alkalinity range (pH 7 to 11) on modified cellulose, little is available on unmodified cellulose or cellulose isolated from wood. Little degradation would be expected during the time required for an analytical determination, but it would seem best to avoid alkaline solutions unless the effect is determined under the specific conditions of interest.

The depolymerization of alkali cellulose represents an interesting contrast to the stabilization of papers by calcium carbonate filler. Shaw and O'Leary (*7*) found that papers containing calcium carbonate were much more stable toward accelerated aging than similar papers containing clay, titanium dioxide, or no filler at all. Hanson (*8*) found in a study of the paper of a sixteenth century book, which contained sheets of the same fiber furnish but in varying states of degradation, that the sheets containing about 2% calcium carbonate were in an excellent state of preservation.

Modified celluloses are usually more susceptible to degradation and are stable over a much narrower range of pH and temperature. The hydrocelluloses represent an exception, as the hydrolysis of cellulose to a lower D.P. presumably changes only the solubility characteristics and crystallinity if the hydrolysis is performed properly (*9*, *10*, *11*). The solubility and ratio of crystalline to amorphous cellulose depend on conditions of hydrolysis. Hydrolysis to a "leveling-off" D.P. represents the extreme in removal of amorphous cellulose leaving an almost completely crystalline residue. The pH range of a medium for the determination of aldehyde in hydrocellulose should be essentially the same as for unmodified cellulose.

Davidson has shown that the periodate oxycelluloses are extremely alkali-sensitive (*12*). A borax solution (pH about 9.2) at 20°C. increased the nitrocellulose fluidity of a periodate oxycellulose from 5.19 to 12.8 rhes (reciprocal poises) in 3 hr. and to 32.9 in 24 hr. A solution of ammonia (200 grams of NH_3 per liter, pH about 13) increased the nitrocellulose fluidity to 26.1 in 1 hr. and to 38.8 in 24 hr. Even boiling water increased the fluidity to 53.5 in 12 hr.

Further work by Davidson (*13*) on alkaline hypobromite oxycellulose and on periodate oxycellulose oxidized with acidic chlorite solution (periodate-chlorite oxycellulose) showed that these acidic oxycelluloses were unstable when their carboxyl groups were in the free acid state. The carboxyl content of the hypobromite oxycelluloses decreased slightly when stored for several months.

Two samples of periodate-chlorite oxycellulose showed considerable increases in fluidity and decreases in carboxyl when steeped in water at 90°C. for 24 hr. The changes due to treatment with 0.2 *M* NaCl or 0.1 *M* NaOH at 90° for 24 hr. were much less.

Davidson (*14*) has found that periodate oxycelluloses are also sensitive to acids, and hydrolysis occurred at much higher pH values than with unmodified cellulose. He used a mixture of sodium chlorite and acetic acid, which has a pH of about 2.9, for oxidizing aldehyde to carboxyl, and this solution did not cause appreciable hydrolysis of periodate oxycelluloses.

Head (*15*) made a systematic study of the alkali sensitivity of the compounds prepared by reacting β-methyl glucoside and β-methyl cellobioside with sodium metaperiodate. He called the derivatives the dialdehyde and the tetraaldehyde, respectively, and they may be considered as mixed acetals of glyoxal and erythrose. The tetraaldehyde was the more alkali-sensitive, and this alkali-sensitivity was attributed to hydrolysis of the acetal linkages. Glyoxal was isolated from alkaline solutions of the tetraaldehyde. Solutions of both aldehydes were unstable in 0.1 *N* NaOH, the aldehyde content decreasing sharply with time. The same was true in 0.1 *N* Na_2CO_3 (pH about 11.0) although not so pronounced, and the tetraaldehyde showed an initial rise in aldehyde content. The dialdehyde was stable in a carbonate-bicarbonate buffer (pH about 9.5), but the aldehyde content of the tetraaldehyde increased about 15% to a maximum within an hour and then decreased to the original value in 24 hr. This shows that the alkaline solution not only creates new reducing groups by alkaline hydrolysis, but also destroys some of the reducing power. A slow decomposition of the tetraaldehyde was observed even in sodium bicarbonate solution (pH about 8.2).

Therefore, the safe pH range of the reaction medium for the determination of aldehyde in periodate oxycelluloses is probably between 3 and 7. The reaction medium should not be much above room temperature unless the effect of a higher temperature on the cellulose is determined. It has already been pointed out that the nature of modified celluloses is seldom known with any degree of certainty, and it is quite possible that celluloses modified by other reagents may contain aldehyde in the 2 and 3 positions.

Difference in Reactivity of Aldehyde in Various Positions

There is no reason to believe that aldehyde in the 1, 2, 3, and 6 positions in the anhydroglucose ring should react in an identical manner. It has been pointed out (*16*) that free aldehyde, as such, cannot be detected in infrared spectra of periodate oxycellulose, and probably exists as a hemi-acetal or hydrate. Gladding and Purves (*17*) found that the reaction rate of

hydroxylamine with sugars and with modified celluloses varied with structure. The rate of reaction of acid solutions of sodium chlorite with various sugars varies over about a tenfold range (*18*). Acidic chlorite also reacts with the aldehyde in cellulose in different positions at different rates (*19*). The effective utilization of this technique might make possible the determination of the location and quantity of aldehyde in the anhydroglucose ring with reasonable accuracy.

Accessibility

The problems of accessibility in the determination of aldehyde in cellulose consist principally of the crystallinity or "order" of the cellulose, rate of diffusion, size of the reagent molecule or ion, and indirectly, conditions under which the aldehyde was originally formed.

Diffusion into the strictly amorphous areas is probably so rapid that accessibility and size of reagent molecule are not important. However, if an appreciable portion of the aldehyde is in the more ordered areas, sufficient time must be allowed for diffusion of the reagent, assuming that the molecule or ion is small enough to penetrate. Water does not change the x-ray pattern of cellulose, and this has been taken as evidence that it does not penetrate the crystal (*6*, p. 42; *20*).

Considerable confusion exists in the literature about the accessibility of various reagents to the crystalline areas in cellulose. It is difficult to assign reactive types with respect to accessibility when reactions occur extensively with hydroxyl groups which exist throughout the cellulose structure. The problem is no less complicated with aldehyde where the position of the aldehyde in the glucose ring is seldom known with certainty and its location in the cellulose fine structure is also obscure.

The conditions under which the aldehyde was first formed are important. In an unswollen condition, cellulose is attacked by most reagents principally in the amorphous areas. If the aldehyde-producing reaction occurs in a swelling medium, it is possible in some cases to take the cellulose through a solvent exchange to prevent collapse (*17*, *21*). The degradation of cellulose by light is probably a case where the effect occurs throughout the fiber with the extent of degradation roughly following Lambert's law, assuming that the reaction is strictly photochemical and involves nothing but cellulose. If the mechanism is affected by impurities, then the photochemical attack will occur in those areas to which the impurities were accessible. In reactions in which recrystallization might occur, as in hydrocellulose formation, aldehyde groups may be covered up in the crystal lattice where they would be less accessible. However, the recrystallization of cellulose has been questioned by Ranby (*22*).

Kinetics and Stoichiometry

Cellulose reactions depend on such variables as the reactant, pressure, temperature, nature of reaction medium, and accessibility. Kinetic studies of cellulose reactions have not been particularly fruitful as the heterogeneity of the reactions and the large number of variables make rigorous interpretation of concentration-time relationships difficult.

An important difficulty with practically all methods for the determination of aldehyde in cellulose is fixing the time for the end of the reaction. An arbitrary time may be selected, as with the copper number test, or the reaction may be allowed to proceed until the concentration-time curve of the unknown parallels that of a cellulose which is considered aldehyde-free. It is frequently impossible to decide whether the reagent is reacting with aldehyde or whether side reactions are taking place. As cellulose, regardless of origin, is a plant product containing at least some natural impurities, the problem of side reactions cannot be ignored. Cellulose derived from wood may be expected to contain a small amount of lignin.

There are no standard celluloses containing known quantities of aldehyde. So far it has not been possible to oxidize cellulose with any reagent and account unequivocally for the aldehyde produced from the amount of oxidant consumed. However, the work of Rist (*23*) on dextrans may point the way toward a more quantitative recovery of oxidant as aldehyde in the reaction of periodic acid with cellulose.

Sugar Units Other than Glucose

Wood cellulose presents an additional problem as the hemicelluloses contain D-xylose, D-mannose, and D-glucose as well as smaller amounts of L-rhamnose, D-galactose and L-arabinose (*1*, p. 371). As these units exist principally in the amorphous areas and are usually accessible, the nature of the reaction of these monomer units with an aldehyde reagent must be known. This is important, as it is well known that sugars do not always react stoichiometrically with oxidants.

METHODS FOR THE DETERMINATION OF ALDEHYDE IN CELLULOSE

A summary of various methods that have been proposed for the estimation of aldehyde in cellulose is given in Table I. A description of analytical methods for the estimation of aldehyde and carboxyl has been given by Purves (*1*, p. 176), and a description of end-group measurements by Stamm (*1*, p. 238).

The Copper Number

None of the copper number methods are included in Table I, because copper number is probably the most empirical of all aldehyde determinations. If used intelligently, it is a good empirical test, but, as indicated previously in this paper, an alkaline solution at or near the boiling point is likely to cause serious degradation with the exception of unmodified cellulose and probably hydrocellulose. In addition, the proportionality of copper number values to aldehyde content is open to question. Methods employing copper reductions in alkaline solution have enjoyed great popularity as indicated by the voluminous data in the literature and the fact that copper number methods are still "on the books" in most collections of standard methods. A brief, but thorough, review of copper number methods has been given by Purves (*1*, p. 176).

The Hypoiodite Method

This method was originally used by Bergmann and Machemer (*24*) as an adaptation of the original Romijn method (*25*) for the iodometric determination of glucose. Harris and co-workers modified the procedure and applied it to a series of hydrocelluloses (*26*) and periodate oxycelluloses (*27*). The following objections

Table I. Summary of Methods for the Determination of Aldehyde in Cellulose

Reagent	*pH*	*Temperature, °C*	*Buffer*	*Sensitivity, millimole*	*Author*	*Reference*
Hypoiodite	9.2	25	Sodium borate, 0.05 *M*	About 0.001	Harris and co-workers	*26, 27*
	About 11	...	Sodium carbonate	.....	Bergmann and Machemer	*24*
Girard reagent[b]	8.5	20–30	Borate	Less than 0.001	Geiger and Wissler	*30*
Potassium permanganate	0.25 *N* in H_2SO_4	0	.....	.....	Hiller and Pacsu	*33*
Potassium cyanide[c]	8.3	Room temp.	Potassium cyanide–ammonium nitrate	Not stated; probably about 0.01	Yundt	*37*
Potassium cyanide	8.5–9.0	39	Potassium cyanide–acetic acid	Not stated, probably about 0.001	Frampton and co-workers	*38*
Potassium cyanide[d]	...	...	Potassium cyanide–sodium carbonate	Probably about 0.0001	Isbell	*39*
Ethyl mercaptan	Conc. HCl	0	Fuming hydrochloric acid	.....	Wolfrom and co-workers	*40, 41*
Hydroxylamine hydrochloride[a]	3–5	Room temp.	System acts as buffer	0.01	Gladding and Purves	*17*
Sodium borohydride	9–9.5	25	NaOH, boric acid, sulphuric acid	0.003	Lindberg and Theander	*43*
Sodium chlorite followed by carboxyl determination	About 2.9	20	Sodium chlorite–acetic acid	Less than 0.001	Davidson	*14*
Sodium chlorite	3.5	40	Acetic acid–sodium acetate	Less than 0.001	Wilson and Padgett	*19*

[a] For the determination of total carbonyl.
[b] Trimethylacethydrazide ammonium chloride.
[c] Method applied to hemicelluloses.
[d] Method applied to dextrans.

may be made to the hypoiodite method: (1) the alkaline medium is objectionable, as discussed previously; (2) a "blank" must be subtracted for the iodine consumed by purified cotton. This is approximately 0.006 millimole of aldehyde per gram of cellulose. Although of little consequence for a high aldehyde content, it becomes important for values in the range of 0.01 millimole per gram; (3) the time-concentration curves for hydrocellulose (*26*) were interpreted as meaning that the reaction was over when the slope became equal to that of purified cotton or of a cellulose pretreated with iodine. This could also be interpreted as a slow reaction with aldehyde in the more highly ordered areas of the cellulose. Pacsu (*28*) and Bates (*29*) pointed out that much of the iodine is transformed to iodate which does not oxidize aldose. In order to ensure a sufficient quantity of hypoiodite in the equilibrium mixture to give complete oxidation of aldose, overoxidation may occur.

Although no extensive testing of the hypoiodite method has been reported, it could be expected to give fair results with celluloses which are not alkali-sensitive.

Girard Reagent

Geiger and Wissler (*30*) have developed a dye absorption method in which a hydrazide (trimethylacethydrazide ammonium chloride or acethydrazide pyridinium chloride) was condensed with the aldehyde in hydrocelluloses. By exchange with dyes (picric acid, for example) a salt was formed which was quantitatively removed with alkali and determined photometrically. It was claimed that the aldehyde end groups estimated by this method gave a number average molecular weight for a series of hydrocelluloses that agreed well with the viscosity average molecular weight.

This dye absorption technique requires about 3 days, makes use of an alkaline buffer, and determines ketonic carbonyl as well as aldehyde. Also, as pointed out by Purves (*31*) and Flory (*32*), there is no reason to believe that number average and viscosity average molecular weights should agree. The method is obviously not generally applicable, although no claims were made for it beyond that of determining aldehyde end groups in hydrocelluloses.

The Permanganate Method

Hiller and Pacsu (*33*) claim that potassium permanganate in 0.25 *N* H_2SO_4 is a suitable reagent for the determination of aldehyde in cellulose, and they applied the method to a series of hydrocelluloses derived from cotton. As mentioned previously (*34*), attempts in our laboratory to determine aldoses by this method gave very low results (about 10% of amount added). If a method is not capable of determining the aldehyde in aldoses such as glucose and cellobiose, it is not likely to be capable of determining aldehyde in cellulose.

Meller (*35*) has shown that the oxygen consumption does not reach a maximum as claimed by Hiller and Pacsu.

Husemann and Consbruch (*36*) have suggested that acid permanganate does not oxidize the terminal groups in cellulose, but only the impurities that are present. They found that raw cotton consumed more permanganate than the same cotton after purification and hydrolytic degradation. D.P. calculated from viscosity measurements showed a decrease from 2500 for the raw cotton to 300 for the hydrocellulose made from it. D.P. calculated from permanganate consumption showed an increase from 250 for the raw cotton to 450 for the hydrocellulose. They found also that glucose, xylose, and some disaccharides reacted only slightly with permanganate under the conditions prescribed by Hiller and Pacsu.

Needless to say, 0.25 *N* H_2SO_4 is too acidic for many celluloses.

Methods Depending on the Cyanohydrin Reaction

The cyanohydrin reaction has been used by several investigators to determine aldehyde in various carbohydrate materials.

Yundt (*37*) has determined the end groups in hemicelluloses by measuring the cyanide consumption at a pH of 8.3. Frampton and co-workers (*38*) have determined aldehyde in cotton cellulose and hydrocelluloses derived from cotton by reaction with cyanide at pH

8.5 to 9.0, followed by steam distillation to hydrolyze the cyanohydrin to ammonia. Isbell (*39*) has developed a method using radioactive tracer techniques with the cyanohydrin reaction to determine the reducing end groups in dextrans. While no criticism is directed toward any of these modifications of the cyanohydrin reaction for the specific applications, the alkaline media required would cast doubt on any results obtained with oxycelluloses.

The Mercaptalation Method

The mercaptalation method was developed by Wolfrom and co-workers (*40, 41*) to study the progress of homogeneous hydrolysis of cellulose in fuming hydrochloric acid. The mercaptalation takes place in strong hydrochloric acid solution as a homogeneous reaction, and the average degree of polymerization is calculated from the sulphur content. Obviously this represents a specific application, and the authors make no claim about the general utility of the method.

Methods Which Determine Total Carbonyl

These methods are included because they can be used in conjunction with aldehyde and carboxyl determinations to obtain information on the distribution of aldehydic, ketonic, and carboxylic carbonyl in cellulose. This approach has been used by Purves (*17; 42; 1*, p. 173) in his work on chromic acid oxycelluloses.

The Hydroxylamine Method. In the hydroxylamine method a measure of the carbonyl in cellulose is obtained from the amount of hydrochloric acid liberated in the reaction of hydroxylamine hydrochloride with the carbonyl (*17, 42*). The method is quantitative for simple carbonyl compounds, and the slightly acidic medium is ideal in that it should cause a minimum of degradation of cellulose. Carboxyl is not measured if present as the calcium salt. The authors do not claim great sensitivity and are skeptical of the complete reaction of ketonic carbonyl in cellulose, but the method is fundamentally sound.

The Sodium Borohydride Method. Lindberg and Theander (*43*) have used the amount of hydrogen produced in the reaction of sodium borohydride with aldoses and ketoses, at a pH of 9 to 9.5, as a measure of carbonyl. Lactones and carboxylic acids do not interfere if they are present as salts. The carbonyl determined by this method on a series of periodate oxycelluloses was about 4% low when compared with the consumption of periodate. It is possible that the nonstoichiometric nature of the reaction of periodate with cellulose and the increase in aldehyde resulting from alkaline hydrolysis of the oxycelluloses tend to balance each other. All celluloses consumed at least 0.02 millimole of borohydride per gram which tends to limit the sensitivity of the method.

The Chlorite-Carboxyl Method

The idea of oxidizing the aldehyde in cellulose to carboxyl with acidic chlorite solution and measuring the carboxyl originated with Harris and co-workers (*27*). They concluded that the reactions of introducing aldehyde into cellulose with periodic acid followed by oxidation to carboxyl with acid chlorite were quantitative, and presented data to show that the carboxyl increase was equivalent to the periodate consumed. Davidson and Nevell (*44*) were unable to duplicate this quantitative relationship, and obtained only about half as much carboxyl as predicted from theory. Davidson (*14*) has attempted to find experimental conditions of chlorite treatment that would give a maximum increase in carboxyl. This approach has much to recommend it; (1) acidic chlorite is supposed to be specific for aldehyde, (2) a mildly acid medium is used (pH near 3), and (3) satisfactory methods for carboxyl determination are available. The only criticism which might be suggested is that water-soluble fragments would be lost.

The Chlorite Method

If chlorite salts in acid solution are specific for the oxidation of aldehyde, an obvious approach is to determine the decrease in titer of a chlorite solution in contact with cellulose. This method shows promise, and some data on aldoses have been obtained (*34, 18*). A progress report on results obtained with cellulose is in preparation.

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Sulphidity in Southern Pine Kraft Pulping

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Laboratory and mill scale studies show that the bursting strength and tear values of pine kraft pulp are not significantly changed when sulphidity in the cooking liquor is decreased from 30 to 20%. With further lowering of sulphidity, changes in pulp strength begin to become noticeable.

A careful study of the literature on the effect of sulphidity in kraft pulping leads to the conclusion that each mill must determine its own optimum operating level. The optimum sulphidity for any mill will depend on its raw materials, its specific operating conditions, and the properties desired in its finished products. Further, the optimum operating sulphidity will be influenced by economic conditions which prevail at any given time. This report summarizes the work which has been done at one mill in an attempt to establish the best operating range for sulphidity. The mill at Crossett, Ark., manufactures high strength, unbleached kraft paper from a mixture of loblolly and shortleaf pine. As a result of increasing efficiency over a period of years, this mill has reduced its salt cake makeup from around 300 to approximately 100 lb. per ton of pulp. As a result of this decrease in salt cake usage, the normal sulphidity of the cooking liquor has continued to decrease. This study has been carried on over a number of years in an attempt to determine the effect of decreasing sulphidity and to establish minimum sulphidity requirements.

The question was not whether high sulphidity was better than no sulphidity but precisely what per cent constituted adequate sulphidity, how much improvement in cooking could be derived from specific increases in sulphidity, or how low could sulphidity go before significantly affecting paper quality. If the precise value of sulphidity could be determined, the economic cost for increasing sulphidity might be evaluated.

One method of compensating for low sulphidity caused by salt cake economy is the addition of elemental sulphur in the recovery system. The exact point of addition varies in different mills, and appears to be a matter of convenience. Sulphur addition to green liquor, to the hearth of the furnace, to salt cake makeup, and to white liquor have been practiced. The authors have no proof of superiority of any one of these methods. The amount of sulphur required depends on the specific mills. Crossett's experience may be summarized by the following equation:

$$\%\ \text{Sulphidity} \pm 2 = 12.85 + 0.035X + 0.12Y$$

where X = pounds salt cake per ton of pulp and Y = pounds sulphur per ton of pulp and per cent sulphidity is based on total alkali. The equation describes the operation of the mill over a period of about 8 years, during which time the sulphidity has varied between 17 and 30% and the salt cake usage between 100 and 300 lb. per ton. From this equation, it may be seen that sulphur is about three times as effective as salt cake in maintaining sulphidity. In other words, when salt cake usage is lowered 100 lb. per ton of pulp, sulphidity is decreased 3 to 4%. If sulphidity is to be maintained, this will require the addition of approximately 30 lb. of sulphur. Typical examples of the extreme ranges described by this equation occurred in January, 1952, when 115 lb. of salt cake gave a sulphidity of 15.3% (calculated 16.9) and in September, 1946, when 250 lb. of salt cake and 40 lb. of sulphur gave a sulphidity of 28.1 (calculated 26.4).

Recovery operation at other mills may result in a different equation. For example, oxidation of black liquor coupled with improved furnace operation can maintain sulphidities at levels higher than indicated by the Crossett equation. One western mill reports 26% sulphidity with 140 lb. makeup; another 21% sulphidity with 80 lb. makeup. A Canadian mill replaces a third of its normal salt cake makeup (320 lb.) with soda ash and caustic to keep its sulphidity below 30%. This last mill oxidizes black liquor for the purpose of reducing odor nuisance rather than to maintain high sulphidity.

EXPLORATORY STUDIES

During the early dates of Crossett's operation, it was observed that higher sulphidities seemed to be related to higher strengths. Some 50,000 individual burst or tear tests on bag and wrapping paper were averaged for periods when sulphidity was either 20 to 24% or 26 to 30%. A 5 to 10% improvement in burst and tear was reported at the higher sulphidity. Not knowing the other variables in this study, the statistical significance of these results cannot be determined.

Subsequently, several series of experimental cooks were made in a small laboratory digester of $1^1/_3$ cu. ft. capacity. The first of these experimental series was carried out over a long period of time with over 100

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cooks being made. The effect of sulphidities over a wide range (10 to 33%) on pulp yield, strength, rate of cooking, hardness of pulp, per cent screenings, active alkali required, etc., was studied.

These experiments confirmed published data which related sulphidity to rate of cooking. At higher sulphidity: cooking was faster; permanganate number was lower for given cooking time and active alkali; or active alkali requirements were lower for a given cooking time and permanganate number. The effect on strength and yield was difficult to evaluate because of contradictory results on duplicate cooks.

The results of this study showed that undesirable effects of reduced sulphidity were more pronounced in the range from 10 to 19% than in the range from 33 to 19%. In fact, the detectable changes caused by sulphidity reduction to 19% were considered too small to warrant the expense involved in maintaining sulphidity above 19%. As a result, sulphidity in the mill was gradually lowered to this point without detecting any ill effects.

As noted above, this study was carried out over a long period of time, and it was necessary from time to time to obtain fresh wood chips. These were taken from the mill supply of wood by careful sampling techniques designed to provide a sample representative of mill chips. In all, five separate lots of chips were used. A statistical analysis of the data disclosed that the variations caused by the different chip lots were greater and more significant than those caused by small sulphidity changes.

Limiting the range of the study to 11 to 19%, another series of cooks was made. In this series, only two lots of chips were used, only a single permanganate level (29 TAPPI) was studied, and only three levels of sulphidity (11, 15, and 19%) were used.

This study showed that cooking was slower at lower sulphidity and the pulp weaker. The two chip lots gave different results as anticipated from previous work; while these differences affected the significance of results, they did not obscure the trend.

Repeating this study with more careful control of chip size, cooking, and pulp evaluation by Valley beater gave similar results. Combining the data gave 23 replicate cooks at each sulphidity level. These cooks were not all identical; there were three cooks at three alkali levels from each sulphidity level; there were three cooks at three different cooking times for each sulphidity level, etc. By combining all of these data and using an estimate for the standard deviation based on a very large amount of data, it was possible to detect a significant difference in bursting strength between 11 and 19% sulphidity. This is shown in Table I, the 95% confidence interval representing 2 sigma limits plus and minus.

Table I. Effect of Increasing Sulphidity in Laboratory Cooks

(Average of 23 cooks at each level)

				95% C.I.
Sulphidity, %	11	15	19	...
Permanganate no.	32.3	30.0	28.7	...
Screened yield	46.3	46.0	45.9	...
Bursting strength (850 S.-R.), %	150.4	153.4	156.7	−1.7
Tear (850 S.-R.), %	244.1	250.0	253.9	−5.0

From these data, it may be concluded that only large changes in sulphidity (as 11 to 19%, for example) will cause a significant change in pulp strength. The next step in our work was to confirm these results on mill scale. Experimental work was planned to carry out suitable experiments in one of the large digesters in the mill, evaluating the results by beater testing of pulp and testing of machine made paper. Yield data are not available on mill scale cooking experiments at Crossett.

MILL SCALE EXPERIMENTS

The Crossett paper mill cooks loblolly and shortleaf pine in direct steamed digesters of 2730 cu. ft. capacity. At the time that this study of sulphidity was made, a cooking cycle of 135 min. to pressure and 70 min. at pressure was used. Steaming was controlled by a pressure control cam as in conventional digester steaming instruments. Relief was controlled manually by the cook. The digesters were loaded by volume, an average of 32,000 lb. of wood (dry basis) being loaded and packed with liquor. About 600 lb. of active alkali (as Na_2O) per ton of pulp (air dry) or 660 lb. per ton (oven dry) were used.

While over half of the digesters in the pulp mill blow into a blow tank with subsequent washing on countercurrent vacuum washers, our major interest was in the

Table II. Effect of Adding Sulphur to Mill Scale Cooks

					Av.					*Av.*
Original sulphidity	21	22	20	20	21	23	22	21	21	22
Sulphur added, lb.	0	0	0	0	0	210	235	265	300	253
Final sulphidity	21	22	20	20	21	30	30	30	30	30
Permanganate no.	24	21	24	23	23	21	23	22	21	22
Rejects	3	2	5	2	3	3	4	5	2	4
Beater test										
Burst (850 S.-R.), %	164	160	172	173	167	171	162	186	175	174
Tear (850 S.-R.), %	254	261	223	238	244	216	214	240	241	228
Summerwood, %	38	39	32	40	37	35	35	33	34	34
Stuff box										
Burst, %	128	131	128	131	130	131	131	133	132	131
Tear, %	321	333	328	326	326	318	329	317	343	324
Headbox										
Burst, %	138	140	143	142	141	133	136	141	143	139
Tear, %	231	266	258	252	257	249	277	280	279	271
Paper (conditioned)										
Burst, %	87	87	88	83	86	88	87	84	82	84
MD tear, %	259	271	288	272	271	250	273	273	274	270
CD tear, %	289	262	278	258	275	295	298	306	278	294

Table III. Effect of Decreasing Sulphidity in Mill Scale Cooking

	High				Av.	Low				Av.
Sulphidity	21	21	21	20	21	16	15	14	15	15
Permanganate no.	21	24	22	19	22	22	29	30	26	27
Lab beater test										
Burst (850 S.-R.), %	161	155	160	152	157	162	144	146	148	150
Tear (850 S.-R.), %	245	236	231	234	237	235	235	262	251	246
Stuff box										
Burst %	111	117	113	114	113	118	117	109	104	112
Tear, %	298	313	321	303	307	282	303	325	314	306
Headbox										
Burst, %	124	128	127	109	120	120	126	129	129	126
Tear, %	202	219	223	234	222	223	210	209	219	215
Paper test										
Burst, %	92	92	91	81	88	83	92	90	87	88
Tear MD, %	242	259	270	232	247	232	224	260	226	236
Tear CD, %	246	244	231	281	257	252	238	248	256	249

pulp washed in diffusers in the older part of the mill. The availability of diffusers and a separate system where experimental pulp could be segregated made it possible to make laboratory type studies on a mill scale with but minimum interference with production. The procedure consisted of cooking both experimental and control cooks in a single digester, storing the pulp in diffusers until the experimental cooking was complete. The diffuser chest and screen room chests would then be pulled down as far as possible, and all of the diffusers representing a specific experimental condition would be dumped. At this time, the pulp could be sampled from each diffuser for laboratory scale evaluation. It was also possible to sample pulp from each cook from the blow line through a small cyclone and these samples could be divided or composited in any desired way. Usually, three samples were taken during the blow to detect any nonuniformity in the cook.

By dumping diffusers containing experimental pulp in quick succession, it was possible to run a paper machine for 3 to 6 hr. on experimental pulp and follow this run with one of equivalent length on a "control" pulp. Some mixing and blending at the beginning and the end of each experimental run was inevitable but in a run of this length, we could be reasonably certain that several reels of paper would be made from each experimental pulp.

The initial mill scale experiment on sulphidity consisted of four cooks at normal sulphidity (20%) interspersed with four cooks to which enough elemental sulphur had been added to raise the "sulphidity" from 20 to 30%. The results as shown in Table II show little or no difference in strength as measured in the laboratory by beater tests or on the pulp in the stuff box or headbox as measured by tests on handsheets, or by tests on machine made paper.

Summarizing the results of increasing sulphidity from 20 to 30%:

Laboratory tests on regulating box stock	no change in bursting strength; no change in tear
Laboratory tests on headbox stock	no change in bursting strength; tear increased 6.3%
Mill paper tested in laboratory after conditioning	bursting strength decreased 1.3%; MD tear—no change; CD tear increased 6.9%
Over-all conclusion	no significant change in pulp quality

Since laboratory studies showed that the effect of sulphidity change was more apparent at low levels, it was considered desirable to operate on a mill scale at 11 and 19% to confirm the small scale work. However, the possibility that a mill inventory of weak pulp would be built up during the period of the test made a general lowering of sulphidity unacceptable to produc-

Table IV. Effect of Increasing Sulphidity in Mill Scale Cooking

Sulphidity, %	Burst, %, Minutes beating						Tear, %, Minutes beating					
	0	5	25	45	65	85	0	5	25	45	65	85
Low Sulphidity Pulp (Jan., 1952)												
14	58	93	146	156	165	162	360	358	226	216	179	163
14	55	92	141	157	161	153	424	316	230	196	181	160
14	65	99	147	157	169	161	403	307	218	174	178	165
14	62	101	145	158	170	164	449	330	233	190	191	174
Av.	60	96	145	157	166	160	409	328	227	194	182	166
High Sulphidity Pulp (Feb., 1952)												
25	65	99	159	177	176	172	357	329	234	199	180	174
25	60	101	158	171	178	163	385	341	227	204	178	162
25	53	94	153	174	177	173	473	371	281	251	201	206
25	51	89	151	176	181	172	478	422	293	229	203	174
Av.	57	96	155	174	178	170	423	366	259	221	190	179
Low Sulphidity Pulp (March, 1952)												
18	50	99	144	168	177	172	437	358	251	191	163	153
18	53	94	151	167	179	171	493	386	244	208	188	174
17	52	95	156	171	181	173	487	371	269	218	195	173
17	60	98	151	171	176	165	502	346	240	192	191	176
Av.	54	96	151	169	178	170	480	365	251	203	184	170

Table V. Machine-Made Paper Testing (Not Conditioned)

Rate	Jan. 28	Jan. 31	Feb. 1	Feb. 3	Feb. 4	Feb. 6	Feb. 7	Feb. 9	Feb. 21	Feb. 25	Feb. 28	Feb. 29
Burst, %	79	78	80	85	81	83	87	85	82	79	83	78
Tear MD, %	195	236	236	190	238	238	188	201	226	185	186	240
Tear CD, %	236	245	248	201	250	265	220	235	247	204	228	245

tion personnel. Since 11% sulphidity was beyond a commercial limit, a study of 15, 20, and 50% was scheduled. The low level was obtained by preparing a zero sulphidity liquor from caustic and soda ash, pumping this liquor to a measuring tank set up specifically for the purpose, and blending this liquor with regular mill white liquor to prepare a liquor charge of the desired composition and strength. The higher than normal sulphidity liquors were prepared by adding the theoretical amount of sulphur directly to the digesters. This represented about 1000 lb. per cook or 130 lb. per ton air-dry pulp.

The 50% sulphidity cooks showed distinct superiority in strength characteristics over the 15% sulphidity cooks and some superiority over the 20% (normal) sulphidity cooks. Since this level is beyond the commercial range, only the 20 and 15% levels are listed in Table III.

Machine-made paper showed a small increase in tear strength at the higher sulphidity level. This difference is not significant; the standard error in duplicating cooks and determining tear strength is greater than these differences. Laboratory tests showed increased bursting strength tests at the higher sulphidity but it may be noted that as great a difference in strength is observed between two sets of control cooks at essentially the same sulphidity as between any other two sets where sulphidity was varied.

One thing that this experiment showed was that production pulp of reasonable strength could be made at sulphidities of 15%. This made it possible to recommend a major, full-scale trial of all of the mill production at two levels of sulphidity, the lower at 15%. It must be realized that such a recommendation would be unacceptable to paper machine operators unless they had some favorable experience in using pulp that had been cooked at low sulphidity.

For a period of several months, the sulphidity was permitted to drop by eliminating entirely the addition of sulphur. Finally the salt cake addition was reduced as low as possible so that for a period of 30 days (January, 1952), the sulphidity never exceeded 16.4% and averaged 15.3%. A record was kept of the paper tests made during this period. Toward the end of the month, eight cooks from an instrument controlled digester were sampled for beater testing. Operating personnel reported difficulty in meeting strength specifications during this month. On the first day of February, sulphur was added to green liquor and to the digesters at the rate of 60 lb. per ton of pulp, while salt cake usage was increased from 115 to 145 lb. per ton. In 4 days, sulphidity to the digesters had risen to 20%. One hundred and ten pounds of sulphur per cook, or 13 lb. per ton, added to the digesters would raise the calculated sulphidity to 25%. As soon as the sulphidity had reached equilibrium (4 days), eight more cooks were sampled from the same digester for beater tests. Finally, beater tests were made in March when the sulphidity had dropped again to 17 to 18%. These results are shown in Table IV.

A statistical analysis of these data shows that there is a highly significant improvement in bursting strength and improvement in tear when sulphidity is increased from 14 to 25%. It is difficult to see any difference when sulphidity drops from 25 to 17 to 18%. The only conclusion we can reach is that only a large change in sulphidity produced an effect that is detectable.

As soon as the sulphidity was increased in February, paper machine operators reported large increases in strength tests and met their strength specifications with ease. A day-by-day average of unconditioned paper tests of 50-lb. paper during this transition period is shown in Table V. In confirmation of the beater test results, the paper test results show some improvement in bursting strength when sulphidity is raised from 15 to 25%. The improvement in tear, not significantly different in the beater tests, did not even show a trend in the paper test results at the different sulphidity levels.

CONCLUSIONS

From the results of laboratory and mill scale experiments, it has been concluded that small changes in sulphidity do not significantly affect the quality of kraft pulp made from southern pine. Both laboratory and mill scale experiments have shown there is no detectable difference in pulp quality when sulphidity, calculated on the total alkali basis, is reduced from 30 to 20%. Laboratory tests have shown there is a significant decrease in pulp quality when sulphidity is reduced from 19 to 11%. However, this change is so small that a replication of approximately 20 cooks was necessary to show it as being statistically significant. A mill scale test in which sulphidity was dropped from 20 to 15% did not show any significant change in pulp quality. Another test in which sulphidity in the mill was raised from 15 to 25% showed an improvement in pulp quality. Therefore, it is concluded that in the range of 25 to 10%, there is some decrease in pulp quality as sulphidity is reduced. This decrease is so small, however that a change of approximately 10% is necessary before it can be definitely detected in mill operations. Other variables such as wood quality, uniformity of cooking, refining, and paper machine operation have more effect on paper strength than small changes in sulphidity.

As a result of this work it has been found possible to operate the mill satisfactorily at a sulphidity range of 17 to 19%; whereas before the work was undertaken, it was not considered possible to operate satisfactorily below 26%.

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Kraft Pulping and Bleaching of Some Southern Hardwoods

D. J. MacLAURIN and J. R. PECKHAM

Bleachable kraft pulps were made from 11 separate southern hardwoods at both constant cooking conditions and constant permanganate number. The pulps were bleached to 80 to 82% G.E. with a modified three-stage (CEH) sequence, in which the second half of the chlorination stage was adjusted to pH 8 to 9 with caustic. The pulps could not be bleached by a standard CEH sequence. Pulping, bleaching, and pulp strength data are given.

THE hardwoods of the southern United States are growing faster than they are being commercially consumed (*1*). Increasing use of them in the pulp and paper industry seems a certainty. A considerable number of experimental pulping and bleaching studies on southern hardwoods have been reported (*2–7*). However, the availability of experimental data, obtained under the same conditions for the kraft pulping and bleaching behavior of an array of separate species referred to baseline commercial experience, is limited. The purpose of this study was to provide such data under selected conditions. The species studied were: post oak (*Quercus stellata*); white oak (*Quercus alba*); blackjack oak (*Quercus marilandica*); water oak (*Quercus nigra*); red oak (*Quercus falcata*); sweetgum (*Liquidambar styraciflua*); black gum (*Nyssa sylvatica*); bay (*Magnolia virginiana*); maple (*Acer rubrum*); ironwood (*Carpinus caroliniana*); and poplar (*Liriodendron tulipifera*). A supply of mill gum pulpwood together with mill unbleached and bleached kraft made from the gum pulpwood were used as reference materials. Experimental kraft cooking conditions were developed which gave a pulp from the mill gum pulpwood with about the same permanganate number as mill pulp from the same wood. Each of the wood species was then cooked using these conditions. Additional modified cooking conditions were then applied to those species whose pulps had permanganate numbers outside the mill range of 14 ± 1. All pulps were evaluated for strength and fiber length classification. Bleach demand tests were run on all of the pulps by treating small samples with a range of amounts of sodium hypochlorite. Using this single-stage bleaching data as a guide, a multistage bleaching sequence was developed and applied to all the pulps produced under the same cooking conditions. These bleached pulps were evaluated for strength and fiber length classification.

PULPING EXPERIMENTS

Freshly cut, sound, pulpwood sticks of each species were hand barked and chipped in a 36-in. laboratory chipper to nominal $^3/_4$-in. chips. These were screened on a 4-mesh screen and the "through" fraction discarded. The remainder was hand sorted to remove large knots and oversize pieces and splinters. Chipping and chips were normal for all of the species except sweetgum and black gum, which had a tendency to yield large cards. The sweetgum cards were broken up by hand. The black gum cards had to be broken up mechanically in a pulp breaker.

The pulping was done in a vertical 45-liter iron digester equipped with forced circulation (11.3 liters per min.) and external indirect heating. Cooks were blown at 85 p.s.i. into a wooden blow tank equipped with a perforated stainless steel bottom. The pulps were washed with three changes of warm water and then screened on a 10-cut laboratory flat screen. Permanganate numbers and beater evaluations for Canadian Standard freeness, apparent density, tear, Schopper tensile and stretch, and TAPPI opacity were run on the screened pulps using TAPPI methods.

The first series of cooks was made using cooking conditions which gave an experimental pulp with a permanganate number of 14.9, from the mill gum pulpwood. This was within the range 14 ± 1 dictated by the permanganate number of 14.3 of the mill pulp from the same wood.

Table I gives the pulping conditions and results from this series at constant pulping conditions. It will be noted that sweetgum, blackjack oak, poplar, bay, and post oak were within the desired permanganate number range, while black gum, white oak, hill red oak, water oak, and maple were overcooked, and ironwood was undercooked. A second pulping series was made, attempting to produce pulps within the permanganate range from those species for which the pulps of the first series were not in range. These data are given in Table II. Beater evaluations were made on cooks 4–15, and 17, 19, 23, 26, 27, and 29. Bauer-McNett fiber classification data on these same pulps are given in Fig. 1. Beater evaluation data are given in Figs. 2 through 5. In all these figures black lines are values for the unbleached pulps.

DISCUSSION OF COOKING AND UNBLEACHED PULPS

Sweetgum, blackjack oak, post oak, poplar, and bay had much the same cooking characteristics as the mill gumwood. Black gum needed only a minor adjustment in cooking conditions to yield pulp in the same permanganate number range as the mill gum. All of the cooks on these pulps had a relatively high residual active alkali in the black liquor. Ironwood was the only species which was markedly more difficult to pulp than the reference pulpwood. White oak, hill red oak, water oak, and maple were considerably easier to pulp than the reference wood. The residual active alkali in the black liquor from these cooks was relatively lower.

The fiber classification tests showed that pulps from these woods covered a wide range of fiber lengths. A grouping of the pulps, based on the sum of the values obtained for +20 mesh and +35 mesh shows that the

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Table I. Cooking Conditions and Product Variables—Pulping at Constant Conditions

	Wood species											
	Mill gum	*Sweet-gum*	*Black gum*	*White oak*	*Black-jack oak*	*Hill red oak*	*Water oak*	*Post oak*	*Maple*	*Poplar*	*Bay*	*Iron-wood*
Cook	4	5	6	7	8	9	10	11	12	13	14	15
Permanganate number	14.9	13.6	10.5	10.4	13.5	10.4	10.9	15.1	12.2	13.8	13.7	15.9
Unscreened yield, %	45.8	44.9	47.3	47.4	41.5	46.7	47.6	44.2	45.3	49.7	45.6	47.1
Screened yield, %	45.7	44.8	47.2	47.3	41.4	46.6	47.5	44.1	45.0	49.6	45.5	47.0
Screenings, %	0.19	0.45	0.03	0.25	0.33	0.17	0.27	0.19	0.66	0.35	0.18	0.22
Black liquor data												
pH	13.+	13.+	13.+	13.+	13.+	12.5	12.5	12.7	12.7	12.9	12.5	12.3
Total alkali (as Na_2O), g./l.	39.2	40.0	38.9	40.0	39.2	36.6	35.3	36.1	36.1	41.4	41.1	43.5
Active alkali (as Na_2O), g./l.	10.2	7.5	10.4	7.4	9.4	5.3	4.9	6.7	7.2	9.2	12.0	8.5

Constant conditions: active alkali (as NaOH), %, 25; sulphidity, %, 28; water ratio (oven-dry wood basis), 4.0; time to max. temperature, min., 190; time at max. temperature, min., 50; blowdown time, min., 15; maximum temperature, °C., 174.

sweetgum and black gum produce the longest fibered pulp, with poplar and bay slightly shorter but in the same range. All of these have somewhat higher values than the mill gum pulped in the laboratory, which in turn had a higher index than the mill pulp. The pulps from white oak and water oak are very similar in fiber length to the laboratory reference pulp, and those from hill red oak, post oak, and ironwood are only slightly shorter. Blackjack oak and maple had appreciably lower values than any of the other pulps, and of these two, the maple was by far the shortest fibered. Varying the cooking conditions did not change the fiber length distributions materially.

The physical properties of the pulps which were cooked under identical conditions are compared in Figs. 2, 3, 4, and 5. These data were interpolated from beater curves. Figures 2 and 3 (which compare these pulps after 20 min. beating) are perhaps indicative of what could be expected were all of the woods combined in equal proportions, cooked, and the pulp evaluated. Using the laboratory mill gum pulp as a baseline, it will be seen that only sweetgum, maple, and ironwood beat faster, and had higher apparent density of handsheets at that point. The other pulps were slower in freeness development than the baseline. The average freeness and apparent density of the eleven pulps were very close to those of the baseline pulp. The tearing strengths of the blackjack oak, maple, and ironwood pulps were inferior to the reference, as might be predicted from the fiber classification data. The rest of the pulps were at least equal to the baseline, and the poplar, hill red oak, and black gum were significantly better. The average tearing strength of the eleven pulps was about the same as for the baseline pulp.

The tensile strength of the reference pulp was exceeded only by that of the sweetgum and ironwood. However, the post oak and blackjack oak pulps were the only ones which were extremely low in this property.

The percentage stretch of all the pulps was higher than that of the reference pulp. The sweetgum pulp had an extremely high value, and the average of the eleven pulps was exactly 50% higher than that of the baseline.

The opacity of the pulps from blackjack oak, maple, bay, and ironwood were higher than baseline, and only those from the two gum woods were significantly lower.

Figures 4 and 5 compare the physical properties of the pulps at a freeness level of 500-ml. Canadian Standard. The reference pulp reached this point after 20 min. beating. The other pulps took from a low of 11 min. for maple to a high of 34 min. for post oak to reach the same point. The average beating time for the 11 pulps was 23 min.

Compared at 500-ml. Canadian Standard freeness, sweetgum, black gum, white oak, hill red oak, and poplar had outstanding tear values. Those of water oak, post oak, bay, and ironwood were in the range of the values obtained for the baseline pulp, and blackjack oak and maple were very low in tear. This is about the same rating the pulps received when compared at a constant beating time. At this freeness only sweetgum and water oak pulps had higher tensile strength than the baseline. Ironwood, bay, poplar, hill red oak, and white oak were somewhat low; post oak, maple, blackjack oak, and black gum were quite low. The sweetgum, black gum, and post oak pulps had very high stretch values, and all of the pulps exceeded the reference value.

Table III compares the properties of the pulps (after

Table II. Cooking Conditions and Product Variables—Pulping to Constant Permanganate Number

	Wood species														
	Black gum	*Black gum*	*White oak*	*White oak*	*Hill red oak*	*Hill red oak*	*Hill red oak*	*Water oak*	*Maple*	*Iron-wood*	*Iron-wood*	*Hill red oak*	*Maple*	*Maple*	*Mill gum*
Cook	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Active alkali (as NaOH), %	25.0	25.0	25.0	25.0	23.25	20.75	19.0	18.5	23.25	26.0	27.0	18.5	21.0	18.5	25.0
Time to max. temperature, min.	190	190	190	170	190	190	190	190	190	190	190	190	190	190	190
Time at max. temperature, min.	20	5	0	0	50	50	50	50	50	50	50	50	50	50	50
Blowdown time, min.	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Total time (cover to blow), min.	225	210	205	185	255	255	255	255	255	255	255	255	255	255	255
Permanganate number	12.5	13.7	11.6	12.2	11.2	11.6	12.0	13.6	12.3	15.3	14.7	12.9	11.5	13.1	14.1
Unscreened yield, %	47.9	49.4	48.7	49.5	47.4	49.6	49.3	51.6	48.5	45.2	45.6	50.2	49.0	50.2	44.5
Screened yield, %	47.8	49.1	48.6	49.3	47.2	49.5	49.0	49.9	47.8	45.1	45.2	48.1	48.4	48.4	44.3
Screenings, %	0.20	0.60	0.31	0.45	0.36	0.38	0.61	3.20	1.38	0.30	1.01	4.15	1.16	3.56	0.32
Black liquor data															
pH	12.4	12.4	12.5	12.5	12.5	11.8	11.8	11.3	12.2	12.2	12.1	11.6	12.4	12.0	13+
Total alkali (as Na_2O), g./l.	42.9	41.1	41.0	42.2	36.3	36.9	31.6	31.8	37.9	44.0	45.0	30.2	33.8	31.3	41.3
Active alkali (as Na_2O), g./l.	12.6	13.7	12.7	13.0	4.1	2.6	3.2	2.7	6.8	9.8	10.5	6.4	4.0	2.9	8.9

Constant conditions: maximum temperature, °C., 174; sulphidity, %, 28; water ratio (oven-dry wood basis), 4.0.

Table III. Physical Properties of Unbleached Pulps of Different Permanganate Number at 20 Min. Beating

Wood species	*Cook no.*	*Permanganate no.*	*Canadian Standard freeness, ml.*	*Apparent density*	*Tear factor*	*Schopper tensile, lb./in.*	*Schopper stretch, %*	*TAPPI opacity*
Black gum	6	10.5	610	12.1	1.90	20.7	4.4	93.2
	17	13.7	610	12.8	1.95	21.0	4.2	89.0
White oak	7	10.4	580	11.1	1.77	20.7	2.8	96.8
	19	12.2	505	11.2	1.72	22.5	3.6	95.8
Water oak	10	10.9	540	12.1	1.62	24.8	2.5	96.2
	23	13.6	395	12.4	1.25	30.8	3.1	95.3
Ironwood	15	15.9	445	13.7	1.33	27.8	4.0	97.5
	25	14.7	500	13.3	1.30	26.0	3.8	97.7
Hill red oak	9	10.4	575	11.4	1.90	22.0	2.7	96.0
	27	12.9	505	11.5	1.67	24.2	2.8	96.3
Maple	12	12.2	405	12.8	1.03	24.5	2.9	97.8
	29	13.1	365	12.8	1.08	28.8	3.5	97.3

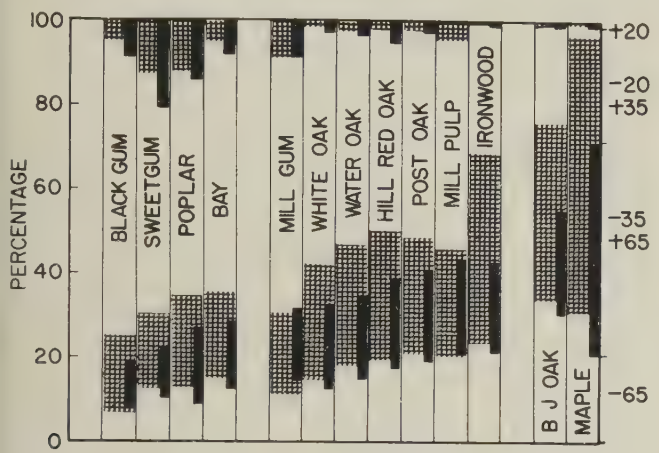

Fig. 1. Bauer-McNett fiber classification data for unbeaten pulps

20 min. beating) of the modified cooks of species for which attempts were made to obtain pulps in the permanganate range 14 ± 1, with the parallel pulps from those species cooked under the constant conditions of Table I.

Single-stage sodium hypochlorite bleach demand tests were carried out at 1.25% oven-dry consistency and 55°C. The data for these experiments are given in Table IV. It will be noted that in many cases the initial pH was adjusted to 8.5 or even 7 with hydrochloric acid and in these cases the system was acidic for nearly all of the reaction period. This was done to increase the bleaching rate, as other experiments on some of these pulps showed that while bleaching rate increased as expected with increasing acidity, the final brightness level was largely independent of pH over the range involved. Probable bleach demand as percentage chlorine to 81% brightness was interpolated from a plot of the bleach demand test data.

Several multistage bleaching sequences were explored before a satisfactory one was established. A CEH sequence on cook 4 pulp involving chlorination at 3.5% oven-dry consistency, 70°F., 1 hr., with 7.4% chlorine; extraction with 2% caustic at 14% oven-dry consistency, 170° F. for 1 hr., and then application of about 3.5% chlorine as hypochlorite at 12% oven-dry consistency, 70°F., for 3 hr., gave a brightness of only 72 to 73% G.E. Variations of the plain CEH sequence were explored but the best brightness reached was only about 75 to 76% G.E. A CCEH sequence on the mill gum pulp involving a first chlorination with 3.77% chlorine (about 95% consumed), a second chlorination with 2.05% (about 60% consumed), 100°F. in the hypochlorite stage, and all other conditions and stages as in the CEH sequence just described, gave brightnesses of 80 to 82% G.E. with 1 to 2% chlorine consumption in the hypochlorite stage. However, it was desirable to bleach to 81% brightness with no more than three stages. This was finally achieved with a CEH sequence wherein the 2-hr. chlorination stage was modified during the second hour by maintaining the pH in the range 9 to 8 by the addition of caustic. The pulps produced under constant cooking conditions were all given this modified CEH sequence, applying 60% of the single-stage hypochlorite bleach chlorine requirement for 81% brightness in the first stage and 0.5% chlorine as hypochlorite in the third stage. The data for these bleaches are given in Table V. Fiber classifications and beater runs were made on the bleached pulps and these data are given in parallel with similar

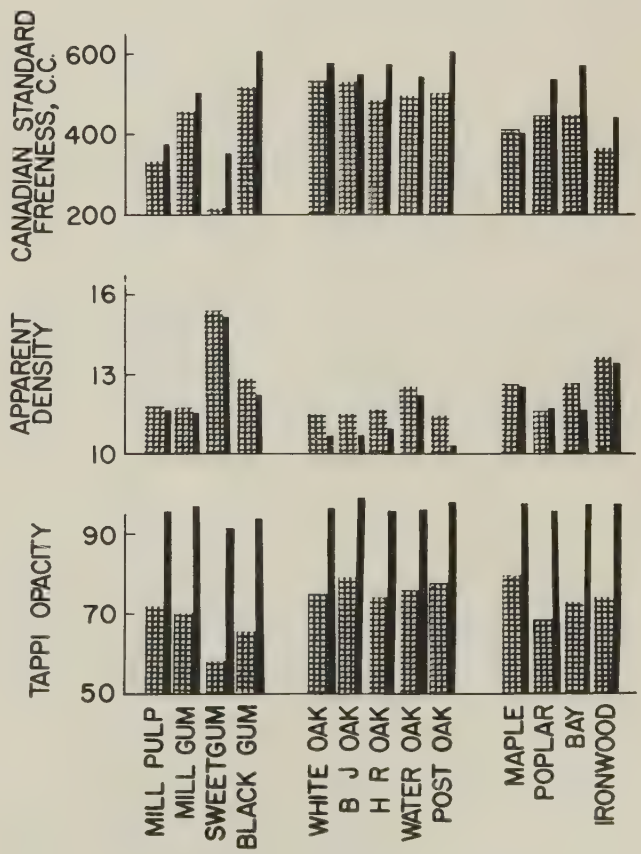

Fig. 2. Physical properties at 20 min. beating (constant cooking conditions)

Table IV. Bleach Requirement Tests

Wood species	*Cook*	*Permanganate no.*	*Chlorine applied (as NaOCl), %*	*Time to exhaustion, hr.*	*G.E. brightness, %*	*Chlorine demand, %*
Mill gum	Mill	14.4	5.2 (d)	1.07	62.2	9.8
			6.9	2.82	72.4	
			8.6	3.60	78.3	
			10.3	3.95	81.3	
			12.0	4.10	81.8	
Mill gum	4	14.9	5.7 (a)	1.37	63.4	11.4
			7.2	3.18	70.8	
			9.0	5.99	76.0	
			10.8	8.00	79.9	
			12.6	9.50	83.0	
Sweetgum	5	13.6	5.0 (b)	0.83	64.3	11.1
			6.6	2.74	71.8	
			8.2	5.40	76.4	
			9.8	9.16	78.8	
			11.4	10.50	76.9	
Black gum	6	10.5	3.9 (b)	0.77	59.7	8.2
			5.1	1.38	69.2	
			6.3	3.72	75.8	
			7.5	6.30	79.5	
			8.7	7.34	80.8	
White oak	7	10.4	3.75 (a)	1.45	66.5	6.6
			5.00	3.92	74.5	
			6.25	7.08	80.4	
			7.50	11.90	84.1	
			8.75	13.92	85.3	
Blackjack oak	8	13.5	4.9 (b)	0.93	61.8	9.8
			6.5	2.60	70.7	
			8.1	6.85	78.9	
			9.7	12.01	80.8	
			11.3	14.11	82.7	
Hill red oak	9	10.4	3.75 (a)	1.50	63.2	7.6
			5.00	3.84	70.7	
			6.25	7.08	76.8	
			7.50	12.00	80.2	
			8.75	13.97	82.1	
Water oak	10	10.9	3.9 (c)	1.48	66.5	6.8
			5.2	4.17	74.5	
			6.5	6.42	79.3	
			7.8	7.90	81.7	
			9.1	11.37	84.6	
Post oak	11	15.1	6.0 (c)	2.47	74.6	8.7
			7.5	4.45	79.4	
			9.0	7.02	81.3	
			10.5	10.80	83.2	
			12.0	12.73	84.1	
Maple	12	12.2	4.3 (c)	0.85	63.7	7.5
			5.8	1.72	73.8	
			7.3	4.13	80.5	
			8.8	5.96	82.5	
			10.3	6.99	82.6	
Poplar	13	13.8	4.9 (c)	1.25	53.7	11.2
			6.6	3.22	67.9	
			8.3	4.78	75.3	
			10.0	6.55	77.6	
			11.7	8.08	80.9	
Bay	14	13.7	5.0 (c)	1.45	58.8	11.9
			6.6	2.54	73.0	
			8.2	3.55	75.8	
			9.8	4.77	77.7	
			11.4	5.47	80.1	
Ironwood	15	15.9	5.7 (c)	1.15	63.8	11.5
			7.6	3.55	75.0	
			9.5	6.38	79.0	
			11.4	9.40	80.9	
			13.3	11.62	80.8	
Black gum	17	13.7	5.0 (c)	1.83	69.3	8.4
			6.6	3.46	77.3	
			8.2	4.92	80.7	
			9.8	6.54	82.3	
			11.4	7.64	84.3	
White oak	19	12.2	4.3 (c)	1.43	69.7	6.6
			5.8	3.33	79.0	
			7.3	4.77	83.0	
			8.8	6.43	85.9	
			10.3	9.75	87.2	
Water oak	23	13.6	4.9 (c)	1.55	64.3	8.5
			6.5	3.52	75.3	
			8.1	5.55	79.2	
			9.7	8.28	82.9	
			11.3	11.27	84.2	
Ironwood	26	14.7	5.2 (c)	1.67	63.1	10.2
			7.0	3.35	74.1	
			8.8	5.68	78.6	
			10.6	8.73	81.7	
			12.4	11.32	81.8	
Red oak	27	12.9	4.7 (d)	0.83	59.0	8.4
			6.2	2.10	73.7	
			7.7	3.24	79.6	
			9.2	3.83	82.5	
			10.7	4.47	83.4	
Maple	29	13.1	4.6 (d)	0.97	63.2	9.5
			6.2	1.88	73.3	
			7.8	3.30	79.2	
			9.4	3.80	83.1	
			11.0	4.17	82.6	

Note: pH control in the series: (a) = no pH control; (b) = HCl to pH 8.5, maintain 8.0–8.5 with NaOH; (c) = HCl to pH 8.5, no further control; (d) = HCl to 7.0, then no further control.

data for the corresponding unbleached pulps in Figs. 1 through 5. In these figures the black lines are values for the unbleached pulps.

The chlorinations were made in a rubber-lined cylindrical container of about 35-liter capacity, equipped with a draft tube. The pulp was circulated by a propeller-type stirrer made from a drill press. Chlorine gas was metered into the center of the container about an inch from the propeller blade, through a rotameter. The chlorinated stock was washed with cold filtered tap water on a muslin-covered washbox and dewatered in a table Büchner. The caustic extraction was done in a glass-lined steam-jacketed Pfaudler stirrer equipped with a planetary-type mixer which gave adequate stirring of the high consistency stock. After extraction the pulp was washed with warm filtered tap water on a muslin-covered washbox and the pulp was partially dewatered. A consistency was obtained and the amount of pulp going into the third stage was

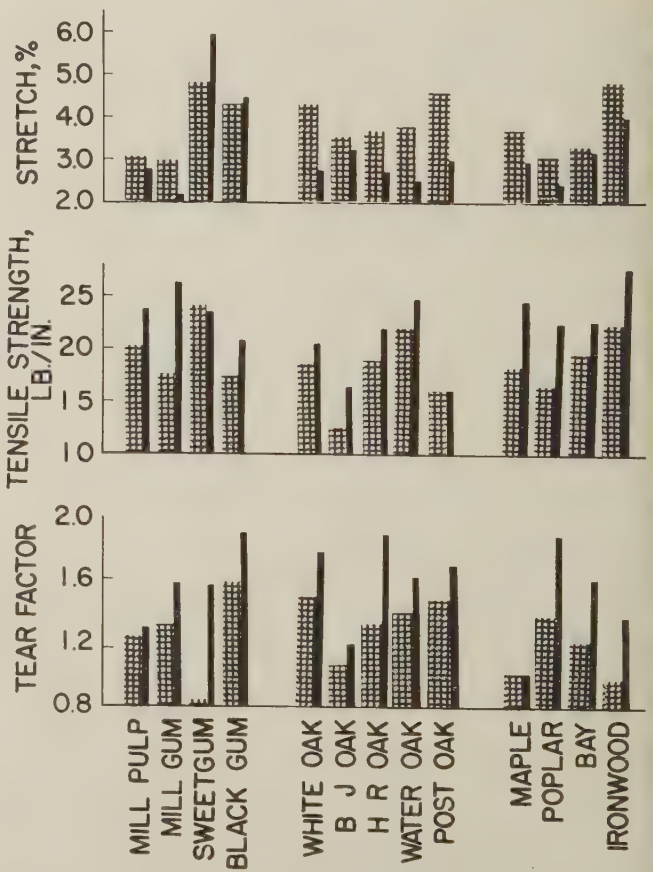

Fig. 3. Physical properties at 20 min. beating (constant cooking conditions)

Table V.—Three-Stage Bleaching of Hardwood Kraft Pulps

Cook	5	6	7	8	9	10	11	12	13	14	15	30	
Bleach	2	1	1	1	1	1	1	1	1	1	1	1	
Wood species	Sweet-gum	Black gum	White oak	Black-jack oak	Hill red oak	Water oak	Post oak	Maple	Poplar	Bay	Iron-wood	Mill gum	Mill gum
Permanganate number	13.6	10.5	10.4	13.5	10.4	10.9	15.1	12.2	13.8	13.7	15.9	14.4	14.4
Chlorine demand, %	11.1	8.2	6.6	9.8	7.6	6.8	8.7	7.5	11.2	11.9	11.5	11.4[a]	9.8
Chlorination													
Chlorine applied, %	6.66	4.92	3.95	5.9	4.56	4.08	5.2	4.5	6.72	7.14	6.9	6.84	5.88
Reaction time, min.	120	120	82	90	120	69	80	63	120	120	90	105	71
Residual chlorine, % of applied	6.84	2.6	...	..	2.56	...	..	..	5.63	9.92	..	...	...
Caustic extraction (standard conditions)[b]													
Hypochlorite stage													
Residual chlorine, % of applied	32.8	27.9	33.9	33.2	45.4	42.2	35.6	..	54.8	42.25	14.0	34.4	7.15
G.E. brightness, %	81.9	85.2	84.2	77.3	82.6	79.5	80.4	82.1	77.7	81.5	83.1	80.8	79.7
Yield													
Unbleached pulp, %	85.9	90.0	93.7	86.7	91.7	93.7	93.6	87.5	94.7	93.6	89.5	86.5	90.5
Oven-dry wood, %	38.5	42.6	44.4	36.0	42.6	44.6	41.4	39.7	47.0	43.6	42.1	40.5	...

[a] Chlorine demand determined for cook 4 was assumed for cook 30.
[b] Standard conditions:

	Chlorination	*Extraction*	*Hypochlorite*
Temperature, °F.	90–85	170	100
Consistency (oven-dry basis), %	3.0	14.0	12.0
Time, hr.	1 hr., then add NaOH to pH 8, then to exhaustion or another hour	1	3
Chemical, %	60% of demand	2.0	0.5

Note: Pulps all given final wash with SO_2 water (pH 5 to 6).

determined. This operation was carried out in 5-gal. earthenware crocks set in a water bath. Stirring was manual. The bleached pulps were washed with warm filtered tap water on a muslin-covered washbox. The last wash was with water of pH 5.5 to 6.0, reduced to this point with sulphur dioxide. The partially dewatered pulps were stored at 40°F. in a cold room in pliofilm bags until tested.

DISCUSSION OF BLEACHING AND BLEACHED PULPS

As would be expected, these hardwood kraft pulps bleached very slowly in single-stage alkaline hypochlorite, and chlorine consumption was relatively high. However, with extended reaction times (4 to 8 hr.) and about 10% chlorine (as sodium hypochlorite), a brightness level of 80 to 82% G.E. could be reached. Reaction rate was increased and brightness level relatively unaffected by adjusting the system pH with hydrochloric acid. The effects of single-stage hypochlorite bleaching on the quality and yield of these pulps was not determined.

Experiments with conventional CEH sequences did

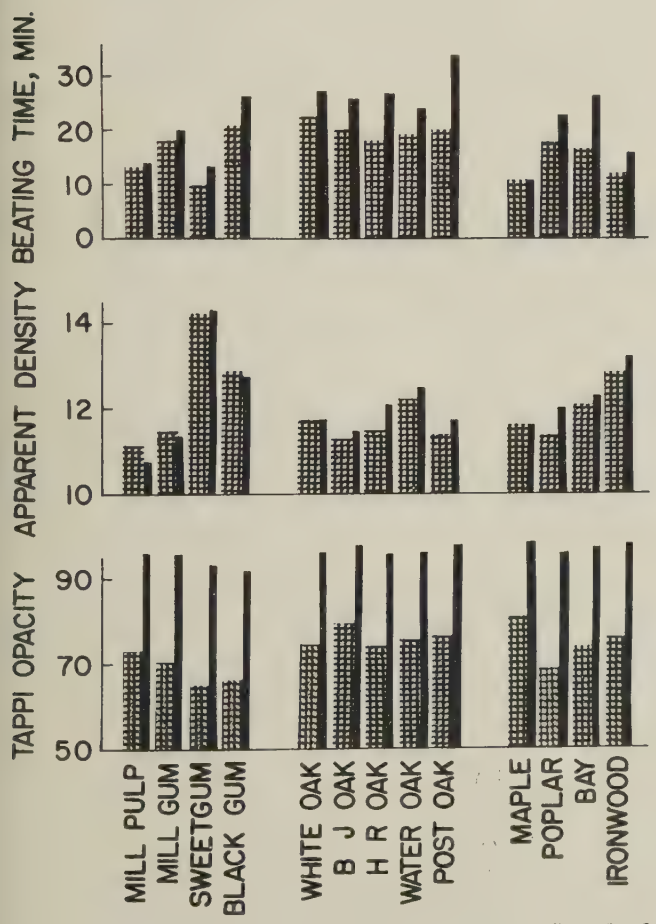

Fig. 4. Physical properties at 500-ml. Canadian Standard freeness (constant cooking conditions)

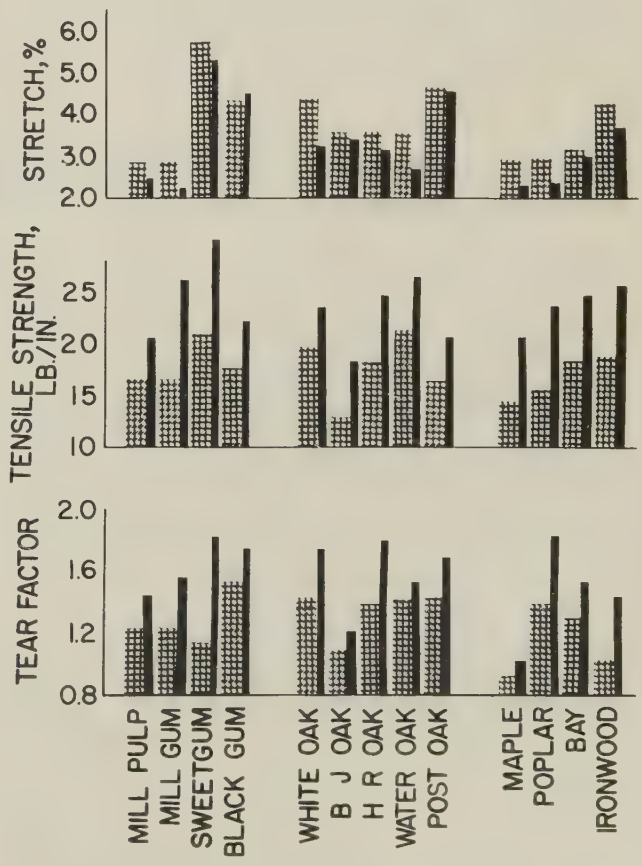

Fig. 5. Physical properties at 500-ml. Canadian Standard freeness (constant cooking conditions)

not achieve brightness levels in the range 80 to 82% G.E., and it is doubtful if they could, because even when considerable excess chlorine was applied in the first stage and large excesses in the third stage, levels of only 72 to 74% G.E. were reached. A CCEH sequence gave 80 to 82% G.E., with reasonable times and amounts of chemical. A modified CEH sequence involving converting chlorine to hypochlorite with caustic in the second half of the first stage gave acceptable bleached pulps of desired brightnesses at reasonable chlorine consumptions.

There was a noticeable variation in the bleaching behavior of the pulps in this modified sequence—particularly, the extent and rate of reaction in the chlorination stage. The sweetgum, black gum, hill red oak, poplar, and bay pulps did not consume the applied chlorine in the full 2 hr., whereas the other species, white oak, blackjack oak, water oak, post oak, maple, mill gum, and ironwood consumed all the chlorine in varying but lesser times. While, in general, it appeared possible to reach the brightness level of 80 to 82% G.E. with application of relatively small amounts of chlorine in the third hypochlorite stage, there were appreciable percentages of the applied chemical unconsumed at the end of the reaction time. Apparently, a significant excess of bleaching agent must be available to drive the reaction. The data do not show any correlation between behavior in the first and third stages.

Bleaching shifted the fiber classification data toward decreasing retention on the coarser and finer screens. As shown in Fig. 1, the shift was greatest for the shorter fibered pulps (blackjack oak, maple, and ironwood).

The physical properties of the modified CEH bleached pulps after 20 min. beating are compared with the parallel unbleached data in Figs. 2 and 3, and at 500-ml. Canadian Standard freeness in Figs. 4 and 5. The values for the bleached pulps are the wider, lighter bars in all cases. It is apparent that the tear, tensile, and opacity of all of the pulps, with either the same time of beating or at the same freeness, was adversely affected by the bleaching operation. The density and stretch of sheets from the pulps increased.

In summary, the pulping and bleaching behavior of the several species studied was not greatly different from that of mill gum pulpwood, with the possible exceptions that ironwood was appreciably more difficult to pulp and poplar gave indications of being more difficult to bleach. The strengths of the unbleached and bleached experimental pulps were generally equal to or better than those of the commercial pulps. The percentage yields of the bleached pulps were on the low side for the shorter fibered blackjack oak and maple.

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An Approach to the Analysis of Latex in Coated Papers

T. E. DUNFIELD and W. H. WATSON

With the increasing use of latex in coating color adhesives it is natural that analytical methods be investigated. This particular approach deals with the quantitative precipitation identification of butadiene-styrene copolymer latex in paper, which yields a rapid test method, using a minimum of laboratory equipment. In its present state of development the test is probably most applicable as an internal mill control, where coating recipe details, coating weight, and the approximate nature of the latex are known. The reactions of polymers other than butadiene-styrene are also considered.

As THE use of synthetic rubber latex in paper coatings expands, the need for an analytical method to determine the amount of rubber in paper becomes increasingly urgent, especially for a method which can be used as a control test for latex content of paper in the coating mill. The object of the present work is to present one approach to this problem which yields a relatively rapid quantitative test method for butadiene-styrene copolymers, and employs only simple laboratory apparatus. The separation and identification of various polymer types is, of course, another problem, and involves a somewhat complicated and lengthy extraction technique followed by an infrared spectrum analysis, giving at best, a qualitative answer. The results described here are of a preliminary nature, and although all the interfering substances and other complications are not known, the data appear promising enough to warrant attention.

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EXPERIMENTAL

The basis for the test method was first suggested by a series of experiments in which coating ingredients, cellulose, clay, casein, starch, and latex were digested individually in concentrated acids. In hot concentrated nitric acid all the materials, except clay, dissolved completely giving clear solutions. This suggested a method for clay separation. Water dilution

of the clear nitric acid solutions showed that the digestion products of cellulose, casein, and starch remained soluble in dilute nitric acid, while that of the latex yielded a yellow precipitate. This result lead to a complete examination of the precipitation caused by diluting nitric acid solutions of latex film. The

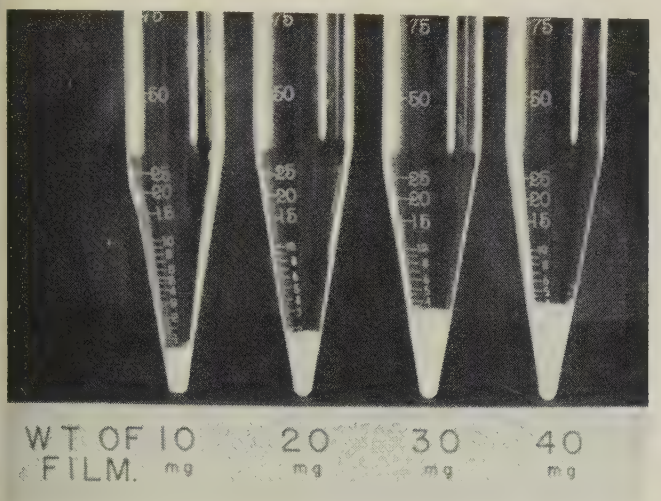

Fig. 1. Centrifuged precipitate from nitric acid solution of latex film

previous results were confirmed, the amount of precipitate apparently being proportional to the amount of film dissolved. In a standardized procedure dried film from Polysar type 333 latex (a butadiene-styrene paper coating latex) which had been cast on glass with a drawbar, was dissolved in 30 ml. of boiling 70% reagent grade nitric acid. The resulting clear solution was cooled in an ice bath for half an hour and diluted with 70 ml. of cold distilled water, forming the precipitate. At first a visual estimate of the amount of precipitate in beakers was obtained, but later it became apparent that an inexperienced operator could obtain improved results by centrifuging the precipitate. The quantitative nature of this precipitation reaction is illustrated in Fig. 1, where 10, 20, 30 and 40-mg. samples of latex film are used. Thus, with a control of known latex content, it is possible to estimate the latex content of unknown samples. It should be emphasized that the results, as shown here, are true for only one set of test conditions, which must be strictly observed.

The digestion time must be very carefully controlled, since the amount of precipitate is known to decrease with increasing digestion time. However, as long as a standard procedure is observed, for both known and unknown samples, quantitative results will be obtained.

Investigation has shown that after 5 min. digestion time the rate of decline in the amount of precipitate is quite rapid and the yields become much lower. A 5-min. digestion step is thus recommended as the best compromise. For accurate timing, place the sample in the nitric acid and heat until brown fumes of nitrogen dioxide first appear and start timing from this point. At the end of 5 min. the sample can be immersed in ice water which will effectively prevent further reaction.

A series of weighed samples of latex film were dissolved and precipitated giving the plot shown in Fig. 2. The centrifuging time can be varied and will shift the position of the line on the graph accordingly. For some of the work to be described in the following sections the precipitate was filtered, washed, dried, and weighed. To check the effect of such handling on the precipitate, a thorough evaluation was made of its drying and heat stability characteristics. Under normal conditions the precipitate is entirely stable. For drying, a vacuum oven is the most rapid method, and at 25 in. of mercury and 120°C., a time of 20 to 30 min. ensures constant weight. Without vacuum 30 to 40 min. are required. Where asbestos-lined Gooch crucibles are used for filtration, longer drying cycles will be required to remove all moisture from the asbestos. Thorough washing of the precipitate with water is necessary before drying, since the presence of free nitric acid causes further reaction during drying and lowers the precipitate yield.

DIGESTION OF COATED PAPERS

The separation of this nitric acid precipitate from a coated paper is more complicated, and to continue the investigation, coating colors were formulated. Details are contained in Table I.

A standard formulation procedure was used starting with the clay slip of about 60% solids, to which was added casein or starch, then the latex, followed by the other ingredients. The variable in the four formulas is the adhesive, being almost equal amounts of latex

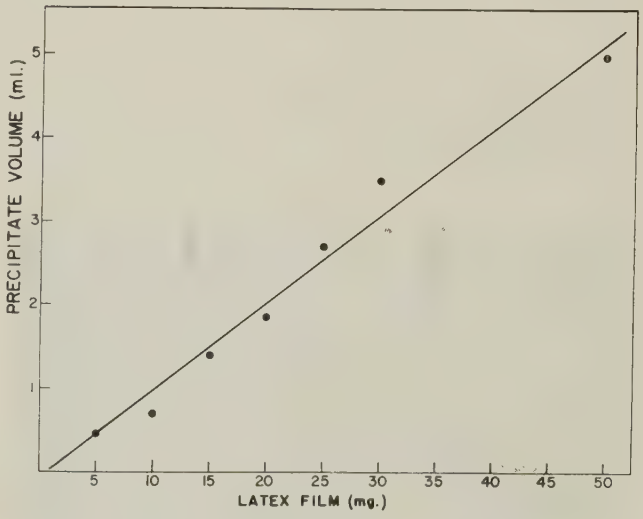

Fig. 2. Volume of centrifuged precipitate versus weight of Polysar type 333 latex film (15 min. at 1400 r.p.m.)

and casein in formula 1A, all casein in 2A, equal amounts of latex and starch in 3A, and a combination of latex, casein, and starch in 4A. Wire-wound drawbars were used to coat raw stock, giving the coating weight as shown. The latex solids content is per cent by weight, based on the total dry coating ingredients.

The analytical procedure for such coated papers was standardized as follows:

Approximately 1.5 grams of coated paper, containing a known amount of coating compound is digested in

30 ml. of boiling concentrated nitric acid for exactly 5 min. This is most conveniently carried out in a 100-ml. beaker covered with a watch glass. The solution is cooled slightly and filtered through a mat of fine asbestos fiber in a "medium" porosity sintered glass crucible. Handling of this hot nitric acid solution is not as hazardous as might be imagined. If the volume of the filter crucible is large enough, the entire solution can be quickly poured into it and the vacuum system (suitably protected with wash and drying towers) does the rest. The combination of sintered glass and asbestos is the best found thus far, sintered glass alone being quickly plugged by the clay. The asbestos also permits quick cleaning and reuse of the sintered glass crucibles. The beaker and filter are washed with about 10 ml. of hot nitric acid. The clay is thus removed. (It should be noted that calcium carbonate, where used as part of the pigment system, will be completely dissolved.) The clear filtrate is cooled for $^1/_2$ hr. and diluted to volume as previously described, to yield the characteristic precipitate which flocculates rapidly. To standardize the procedure the precipitate was further cooled undisturbed for $^1/_2$ hr.

Table I
Coating color formulas (dry parts by weight)

	Recipe no. 1A	2A	3A	4A
Clay	100	100	100	100
Sodium hexametaphosphate	0.5	0.5	0.5	0.5
Polysar type 333 latex solids	7.5	Nil	7.5	3.5
Casein solution solids[a]	8.7	17.4	Nil	4.6
Starch solution solids	Nil	Nil	7.5	7.5
Defoamer/stabilizer	0.6	0.6	0.6	0.6
Ultramarine blue	0.2	0.2	0.2	0.2
Total solids, %	48	40	51	46
Coat weight: dry lb./ream (25 × 38—500)	27	25	33	24
Latex solids content, %	6.38	Nil	6.45	2.94

[a] Includes alkali, buffer and preservative.

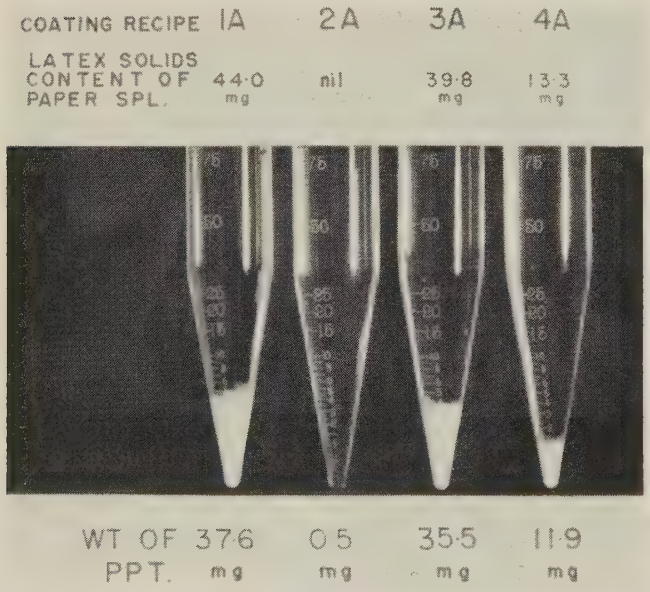

Fig. 3. Precipitates from 1.5 g. of coated paper

The amount of precipitate can be measured in centrifuge tubes or filtered through asbestos in a Gooch crucible, dried, and weighed. Results of both methods are shown in Fig. 3. The gravimetric analysis shows very promising results, there being a direct relationship with the calculated latex solids content of the sample. The sample size can be adjusted to yield almost any amount of precipitate, although a larger sample means more clay to filter off, which may be troublesome. The small amount of precipitate in 2A which contains no rubber can be attributed to traces of aromatic materials, the amount being so small that it will not affect the results.

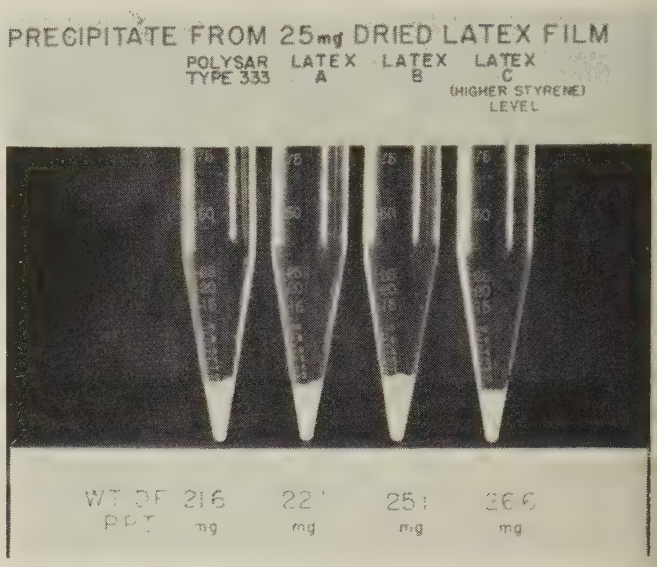
PRECIPITATE FROM 25mg DRIED LATEX FILM
POLYSAR TYPE 333 LATEX A LATEX B LATEX C (HIGHER STYRENE) LEVEL
WT OF PPT 21·6 mg 22·1 mg 25·1 mg 26·6 mg

Fig. 4. Polysar type 333 and other butadiene/styrene paper coating latices

Table II
Coating color formulas (dry parts by weight)

	Recipe no. 1B	2B	3B	4B	5B
Clay	100	100	100	100	100
Sodium hexametaphosphate	0.5	0.5	0.5	0.5	0.5
Polysar type 333 latex solids	1.0	3.0	6.0	10.0	14.0
Casein solution solids[a]	8.3	8.3	8.3	8.3	8.3
Ultramarine blue	0.2	0.2	0.2	0.2	0.2
Total solids, %	45	44	45	44	44
Coat weight: dry lb./ream (25 × 38—500)	16	12	13	14	14
Latex solids content, %	0.91	2.68	5.22	8.40	11.4

[a] Includes alkali, buffer, preservative and defoamer.

Table II shows a series of coatings with all ingredients constant except the latex which varies from 1 to 14 parts per 100 parts clay, or expressed as a function of all dry coating ingredients, from 0.91 to 11.4%. Preparation of the coating colors and the coated paper was carried out as previously described. It should be pointed out that the first series of coated papers as showed in Table I were calendered. The series in Table II were not calendered. This has not affected the test results. The coated papers were analyzed giving the results summarized in Table III.

For a more accurate reading on recipes 1B and 2B larger initial samples would have been preferable.

Table III. Nitric Acid Digestion of Coated Papers

	Coating formula no.				
	1B	2B	3B	4B	5B
Latex solids/100 parts clay	1	3	6	10	14
Sample weights, g.	1.47	1.82	1.38	1.40	1.40
Latex solids content, mg.	3.4	9.7	15.0	26.1	35.9
Weight of final precipitate, mg.	4.3	7.0	14.8	22.9	31.7

Weights of precipitate in the range of values shown for 4B and 5B have been found satisfactory. Sample weights varied only as a matter of convenience. However, the direct relationship between the weight of precipitate and the latex solids content can again be seen—the weight of precipitate being about 85 to 90% of the weight of the latex solids content. The extra time involved in the gravimetric determination can be justified where a higher degree of accuracy is desired.

GENERAL CONSIDERATIONS

The fact that Polysar type 333 gives a precipitate which is about 85 to 90% by weight of the latex solids content is a chance function of styrene content and polymer structure. Other butadiene-styrene paper coating latices will give almost the same results although, as shown in Fig. 4, some variation may be expected if the styrene level or polymer structure is not the same. Latex A and Polysar type 333 are latices commonly used in the paper coating industry, and this precipitation test shows that they are interchangeable in this test. Latex B is a similar type but is believed to differ somewhat in structure, giving a higher amount of precipitate under similar test conditions. Latex C shows the effect of a higher styrene level; the weight of precipitate is proportionately higher although the higher density of the precipitate actually causes a lower volume reading. A test on the latex film itself is the most convenient means of finding the precipitate yield to be expected for any given type. Such control results can be used in evaluating actual latex content of paper samples.

Table IV. Nitric Acid Reaction with Various Types of Polymers

Polysar type 333	Positive (high yield)
Polysar type II	Positive (low yield)
Polysar butyl	Negative (insoluble in HNO_3)
Polysar acrylonitrile type	Negative (too low yield)
Polystyrene	Interferes (partially soluble—high yield)
Polybutadiene	Negative (No precipitation)
Natural rubber	Negative (No precipitation)
Acrylate	Positive (low yield)
Neoprene	Negative (too low yield)

The nature of the precipitate is of interest and is being investigated, but as yet the complete structure is not known. It is evident that the presence of any precipitate is dependent principally on the styrene portion of the polymer, and that the amount of precipitate is, to some extent, governed by the polymer structure, i.e. the molecular weight and cross-linking. It is also apparent that it is a nitro compound, probably a polymer of low molecular weight. Some of these facts are borne out by the reaction of various polymer types listed in Table IV.

Polysar type 333 paper coating latex gives a positive precipitation considered for purposes of this test as a high yield. Polysar type II latex with a lower styrene level yields a positive test but a lower amount of precipitate, the amount being proportional to the styrene content of the polymer. Butyl rubber is insoluble in nitric acid and will be filtered off as insoluble material. The acrylonitrile types give a small yield, which can be considered negative for purposes of this test. Polystyrene is called interfering because of only partial solubility in nitric acid under the conditions of the test. The portion which dissolves will show a quantitative precipitate as would be expected. Natural rubber and polybutadiene normally contain no cyclic compounds and do not precipitate. A rather interesting result of heat aging natural rubber and polybutadiene films (24 hr. at 120°C.) is that the natural rubber still gives no precipitate—a negative reaction—while the polybutadiene gives a small amount of precipitate. This agrees with the usual concept of aging of these materials, the natural rubber being degraded by heat (to lower molecular weight) while the polybutadiene would tend to resinify which could include some cyclization (higher molecular weight) giving a positive reaction in this test. Acrylates are positive but of low yield, and neoprene, as a rule, is negative. There are a number of varieties of neoprene and thus far only a few have been examined. Other cyclic compounds, such as emulsifiers, may give a small amount of precipitate. It is doubtful if they would be used in a large enough amount to seriously affect the results.

From these results it can be assumed that natural rubber, acrylonitrile types, and some neoprene types can be present in the raw stock without interfering with the determination of butadiene-styrene copolymers in the coating. Other types of polymers may interfere, but probably a correction factor could be applied if uncoated raw stock were available. These qualifications make the test method of doubtful reliability in its present state of development when the nature of the rubber-resin in the raw stock or in the coating is completely unknown. Work is underway to resolve this difficulty. This offers no problem in using the test method as a process control tool. In this it is merely necessary to establish the amount of precipitate to be expected by testing the latex in a standard procedure, and then applying the factor so determined to the analysis result for a piece of coated paper, using exactly the same procedure.

FUTURE WORK

A statistical analysis of a large number of tests is planned as well as continuing work on the identification of the precipitate. Problems, such as the analysis of complete unknowns and the separation of polymer content of raw stock and coating, are in process of examination. The writers would welcome any suggestions as to further study of this problem from those engaged in the paper coating field.

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Reaction of Sodium Chlorite with Some Aldoses and Modified Celluloses

WILLIAM K. WILSON and ALICE A. PADGETT

The reaction of sodium chlorite with eight aldoses and with some modified celluloses was studied in solutions buffered to pH 3.5 at 40°C. at a chlorite concentration of 0.005 *M*. The aldoses were rhamnose, galactose, mannose, glucoheptose, and the aldopentoses. The reactions all appear to be first order with respect to aldose and, at a sugar concentration of 0.25 millimolar, to require approximately 3.6 moles of chlorite per mole of sugar. The number of moles of chlorite required to react with 1 mole of xylose appears to decrease with increasing xylose concentration. The decrease in titer of 0.005 *M* sodium chlorite buffered to pH 3.5 at 40°C. has been used as a measure of the aldehyde content of modified celluloses. Values obtained by this method for hydrocelluloses and periodate oxycelluloses agree fairly well with the carboxyl increase due to chlorite treatment. The aldehyde content of cellulose derived from wood is rendered uncertain by the presence of residual lignin.

THE reactions of sodium chlorite with several aldoses and with modified celluloses have been studied, with a view to using the results obtained with simple sugars in interpreting those obtained with the modified celluloses.

REACTION OF ALDOSES WITH SODIUM CHLORITE

The pioneer work on the reaction of chlorites with carbohydrate materials was reported by Jeanes and Isbell (*1*). They showed that the reaction with aldoses could be represented approximately by the equation

$$RCHO + 3HClO_2 \rightarrow RCOOH + 2ClO_2 + HCl + H_2O$$

and that the study of the reactions was complicated by the decomposition of chlorite in acid solution. Ketoses, polyhydroxy alcohols, and aldonic acids were attacked only after several days' treatment with chlorite solutions. They found that chlorine dioxide reacted slowly or not at all with aldoses.

The reaction of glucose and some disaccharides with acidic solutions of sodium chlorite was considered in an earlier paper (*2*). Under the experimental conditions used, the decomposition of acidic chlorite solutions was found to be approximately second order, and the oxidation of glucose and cellobiose to be first order with respect to sugar and to chlorite. It was shown that glucose could be determined by measuring the change in chlorite concentration iodometrically or by measuring photometrically the chlorine dioxide produced. With either method it was necessary to correct for the decomposition of the chlorite in acid solution. Glucose, cellobiose, maltose, lactose, and melibiose were all oxidized by sodium chlorite at pH 3.52 at about the same rate. This is not surprising as the reducing half of all four disaccharides is glucose.

In the present study data were obtained on the following sugars: arabinose, xylose, lyxose, ribose, rhamnose, galactose, mannose, and glucoheptose. Ribose and lyxose were obtained from a laboratory supply house and were described as 98% pure. The others were supplied through the courtesy of H. S. Isbell of the National Bureau of Standards.

EXPERIMENTAL CONDITIONS AND PROCEDURE FOR ALDOSES

The experimental conditions used in this study were essentially the same as those used earlier in preparing a calibration curve for glucose (*2*). Control solutions were run along with test solutions (the solutions containing aldose) in order to correct for the decomposition of chlorite. The solutions were buffered to a pH of 3.52 by means of a sodium acetate–acetic acid buffer. A small quantity of sodium oxalate was added to prevent catalytic decomposition of chlorite by traces of ferric ions (*2*).

The experimental conditions are summarized as follows:

Temperature	40° ± 0.1°C.
pH	3.52
Chlorite concentration	0.005 *M*
Aldose	ca. 0.25 millimolar
Composition of buffer (for 1 liter)	
Sodium acetate, $NaC_2H_3O_2(H_2O)_3$	55 ± 0.2 g.
Acetic acid, glacial	315 ± 3 g.
Sodium oxalate	0.5 ± 0.1 g.
Composition of test solution (for 1 liter)	
Buffer	250 ml.
Sodium chlorite, 0.04 *M*	125 ml.
Aldose	ca. 0.25 millimole
Water	To make 1 liter
Composition of control solution (for 1 liter)	Same as test solution, but without aldose

In addition to the above conditions, ribose and mannose were reacted with 0.01 *M* chlorite, and xylose was reacted with 0.005 *M* chlorite over a range of 0.125 to 1 millimolar xylose.

The buffer was prepared by dissolving the sodium acetate and sodium oxalate in water, filtering through fritted glass, adding the acetic acid, and diluting to 1 liter in a graduated cylinder. It was made up fresh each week and kept under refrigeration.

The reactions were followed by taking aliquots from a large volume of solution, or by preparing several solutions, each 40 ml. in volume, in 250-ml. glass-stoppered flasks. In the former case the solutions were mixed, except for the chlorite solution, in 1-liter

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wash bottles and allowed to warm to 40°C., and the chlorite solution was added. Aliquots were taken at intervals by blowing about 40 ml. into a graduated cylinder and removing 25 ml. with a pipet. The chlorine dioxide was removed by bubbling CO_2, air, or N_2 through the solutions for 6 to 10 min. After adding 50 ml. of 10% KI and 5 ml. of 6 *N* HCl, the liberated iodine was titrated with 0.025 *N* thiosulphate.

STOICHIOMETRY OF THE REACTION OF CHLORITE WITH ALDOSES

It has already been pointed out (*2*) that subtraction of the chlorite consumed in the control solution from the chlorite consumed in the test solution results in an overcorrection for the decomposition occurring in the test solution. This error becomes greater as the sample size is increased and is greater for longer reaction times. This overcorrection can be avoided by use of a calibration curve, or by calculating glucose by a formula derived from the kinetics of the oxidation and decomposition reactions, assuming that 1 mole of glucose requires 3 moles of chlorite for oxidation to carboxyl. This formula

$$A_o = \frac{C_o}{3}\left(1 - \frac{C_T}{C_c}\right)$$

gave good results for glucose. A_o is the glucose concentration in millimoles, C_o, C_c, and C_T are the concentrations of chlorite in millimoles initially, in the control solution, and in the test solution, respectively. The formula is applied to the analytical data as the reaction nears completion, and the calculated values of A_o become fairly constant with time. The 3 refers to the moles of chlorite required to oxidize 1 mole of glucose. If the 3 is omitted, the expression $C_o[1 - (C_T/C_c)]$ is the measure of the moles of chlorite consumed by aldose. This expression is used in this paper as one method of calculating the amount of chlorite consumed by a given quantity of sugar. The data were calculated from time-concentration plots for each sugar. Using this expression, the calculated values of chlorite consumed by the sugars usually went through a maximum and tapered off slightly, but this appeared to be within the limits of experimental error.

It is possible to make an adjustment in the overcorrection that results from subtracting the control curve from the test-solution curve. From the control curve the rate constant for the decomposition is calculated. From this constant and from an estimated average chlorite concentration in the test solution (from the test-solution curve) the decomposition in the test solution is calculated. This procedure is too cumbersome for routine use, and was used only to check the results obtained with the formula $C_o[1 - (C_T/C_c)]$.

EXPERIMENTAL RESULTS AND DISCUSSION

The data in Table I were calculated from rate experiments for each sugar. Data for the oxidation of ribose are plotted in Fig. 1. The net curve in Fig. 1 was obtained by subtracting the control curve from the test-solution curve. The failure of the control curve to go to the origin, observed with some of the sugars, is probably due to impurities in the reagents. In as much as the net curve rises to 0.895 millimole chlorite for 0.25 millimole ribose per liter, it appears that the stoichiometry is different from that of the reaction of chlorite with glucose, which requires approximately 3 moles of chlorite per mole of sugar. The term stoichiometry is used rather loosely here to describe the ratio of chlorite consumed to aldose added, and no account is taken of the actual products of the reactions or of side reactions.

Table I (columns 5, 6, and 7) gives the chlorite consumption of the various sugars as calculated by the

Table I. Reaction of Sugars with Sodium Chlorite

Sugar	Time for completion, hr.	Rate constant, k, liter mole^{-1} sec.$^{-1}$	Sugar, millimole[a]	Chlorite consumed by sugar: Method 1: control minus test solution, millimole	Method 2: corrected control minus test solution, millimole	Method 3: from formula $C_o[1 - (C_T/C_o)]$, millimole	Ratio: moles chlorite to moles sugar: Method 1	Method 2	Method 3
				Pentoses					
L-Arabinose	2–3	0.17	0.00625[b]	0.0226	0.0232	0.0234	3.62	3.71	3.75
			0.0050[c]	0.0177	0.0183	0.0181	3.56	3.66	3.62
D-Xylose	3–4	0.097	0.00625[b]	0.0225	0.0235	0.0236	3.60	3.76	3.78
	3–4	...	0.0100	0.0342	0.0358	0.0357	3.42	3.58	3.57
D-Lyxose	2–3	0.17	0.0100	0.0354	0.0363	0.0361	3.54	3.63	3.61
D-Ribose	2–3	0.15	0.0100	0.0358	0.0364	0.0365	3.58	3.64	3.65
	1–1 1/4[d]	0.14	0.0100	0.0369	...	0.0374	3.69	...	3.74
				Methylpentose					
L-Rhamnose	7–9	0.035	0.00625[b]	0.0210	0.0225	0.0224	3.36	3.60	3.58
				Hexoses					
D-Galactose	4–6	0.066	0.00625[b]	0.0204	0.0214	0.0215	3.26	3.42	3.44
D-Mannose	6–8	...	0.00625[b]	0.0206	0.0220	0.0217	3.30	3.52	3.47
	6–8	0.050	0.00625[b]	0.0220	0.0238	0.0231	3.52	3.89	3.70
	2 1/2–3[d]	0.052	0.0100	0.0345	...	0.0361	3.45	...	3.61
D-Glucose	...	0.017[e]	...	...	...	...	...	...	...
				Heptose					
D-Glucoheptose	4–6	0.074	0.0100	0.0342	0.0359	0.0358	3.42	3.59	3.58
						Average			3.62
						Standard deviation			0.10
						Standard deviation of replicates			0.11

[a] Sugar concentration was 0.25 millimolar except for second experiment with arabinose, which was 0.125 millimolar.
[b] 25-ml. aliquots from liter wash bottles; all others 40 ml. of solution in 250-ml. glass-stoppered flasks.
[c] No oxalate in this experiment.
[d] Chlorite concentration = 0.01 *M* for these experiments.
[e] Value calculated from data in reference (*2*).

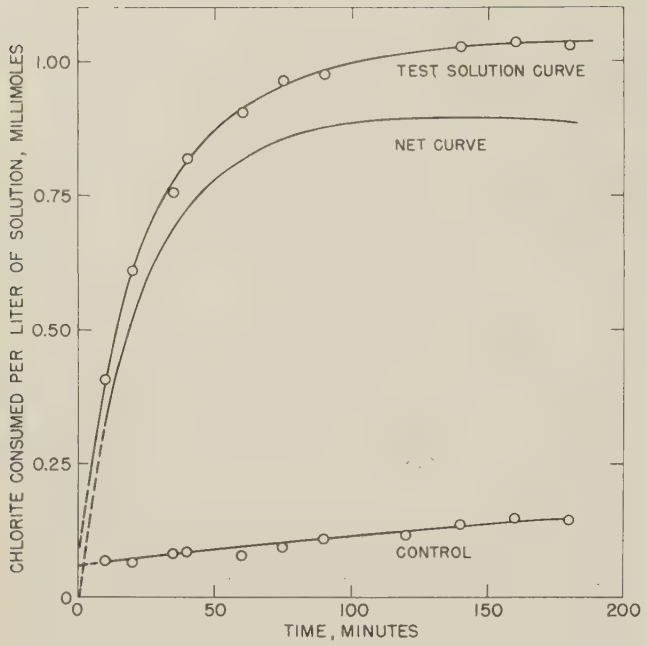

Fig. 1. Oxidation of 0.25 millimolar ribose with 0.005 M sodium chlorite buffered to pH 3.52 at 40°C.

three procedures discussed above. The ratios of moles of chlorite to moles of aldose are given in the last three columns of the table. The values in the last column, method 3, are probably the most accurate. Methods 2 and 3 show agreement that is considered to be within the limits of experimental error with the exception of one experiment with mannose. The standard deviation of the ratio for replicate runs (method 3) is 0.11, and the standard deviation of the ratio, considering all the data in the last column as one set, is 0.10. These deviations from the average value, 3.62, of the ratios in the last column are so small that it is probable that all the sugars listed in Table I exhibit the same stoichiometry in reacting with chlorite under these particular experimental conditions. This could be considered as evidence that all the sugars in Table I are oxidized by chlorite by the same mechanism, and that glucose may be oxidized, at least in part, by a different mechanism.

Table II gives the ratios of moles of chlorite to moles of xylose, as determined by method 3, for several different concentrations of xylose. The decrease in the values of the ratios with increase in sugar concentration indicates that the stoichiometry of the reaction changes with xylose concentration. It would appear that the only practical way of using the chlorite method for the determination of xylose, and probably the other sugars considered in this paper, is to prepare a calibration curve relating sugar concentration to chlorite consumed

Table II. Reaction of Xylose with Sodium Chlorite[a]

Xylose added, millimole	*Concentration of xylose, millimolar*	*Chlorite consumed by xylose from formula, $C_o[1 - (C_T/C_o)]$, millimole*	*Ratio: moles chlorite to moles xylose*
0.005	0.125	0.0182	3.64
0.010	0.250	0.0357	3.57
0.020	0.500	0.0677	3.38
0.030	0.750	0.0981	3.27
0.040	1.000	0.1289	3.22

[a] 0.005 *M* sodium chlorite.

Table III. Correlation of Rate of Reaction of Sugars with Chlorite with Polarographic Behavior and with Mutarotation Velocity

Sugar	*Mutarotation coefficient[a] ($k_1 + k_2$) × 10^3, 20°C., water solution*	*Amount of reducible form at pH 6.5 at 25°C.,[b] mol %*	*Rate constants[d] at 25°C. for ring → aldehyde transformation in 0.5 M aldose solutions at pH 7.75, sec.$^{-1}$*	*Time to oxidize half of sugar by chlorite at pH 3.52 at 40°C., hr.*
Glucose	6.3	0.012	6.4	2.8[c]
Mannose	17.5	0.040	14.7	0.87
Galactose	...	0.070	23.2	0.62
Xylose	20.3	0.10	52.0	0.43
Arabinose	...	0.13	65.5	0.24
Lyxose	58.0	0.15	...	0.22
Ribose	...	10.00	...	0.28

[a] From reference (*5*).
[b] From reference (*3*).
[c] The value for glucose is from reference (*2*).
[d] From reference (*4*).

(net curve) for a definite time period in the same manner as described for the determination of glucose (*2*).

Figure 2 shows semi-log plots of the unoxidized sugar (in per cent) in the presence of excess chlorite against time. Although this is not a sensitive method for obtaining information about the order of a reaction, all of the plots, like those for glucose and cellobiose (*2*) indicate a first order reaction with respect to aldose. Ribose, lyxose, and arabinose all react at about the same rate, but xylose definitely reacts more slowly than the other three pentoses. Rhamnose, the two hexoses, and glucoheptose react more slowly than xylose.

Approximate values for constant k are given in Table I. The average value of the large excess of chlorite is taken as a constant. Integrating the rate equation

$$-\frac{dA}{dt} = kAC$$

one obtains

$$\log A = -\frac{kC}{2.303}t + \text{const.}$$

where A is aldose concentration, t is time, and C is chlorite concentration. From a plot of log A against t,

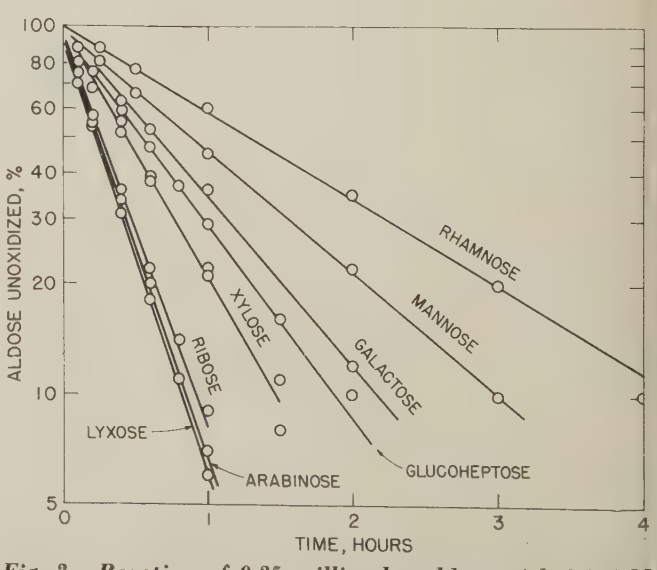

Fig. 2. Reaction of 0.25 millimolar aldose with 0.005 M sodium chlorite buffered to pH 3.52 at 40°C.; determination of order with respect to aldose

$$k = -\frac{2.303m}{C}$$

where m is the slope of the line.

The polarographic behavior of aldoses has been interpreted by Cantor and Peniston (*3*) as a measure of the amount of reducible form in solution in equilibrium with the ring form and by Delahay and Strassner (*4*) as the rate of transformation of the ring to the aldehyde form. Table III contains data from Cantor and Peniston on the amount of reducible form in solution and values for K_s, the rate constant for transformation of the ring to the aldehyde form, given by Delahay and Strassner. Mutarotation coefficients, $k_1 + k_2$, from the data of Isbell and Pigman (*5*) and the time required for oxidation of half the sugar by chlorite are also given in Table III. k_1 and k_2 are the specific rate constants for the conversion of the alpha form to the beta form and vice versa, respectively. Mutarotation data are not given for those sugars which exhibit complex mutarotation. Table III shows that the mutarotation and polarimetric data correlate with the rates of reaction with chlorite for the sugars studied except lyxose and ribose.

It must be emphasized that the data in Table III were obtained by different investigators under various experimental conditions.

Jeanes and Isbell (*1*) have discussed the possibility that chlorite oxidizes the ring form of sugars directly to the lactone without going through the free aldehyde stage. This has been proved for bromine oxidation (*6*, *7*) but experimental difficulties made it impossible to obtain this information for chlorite oxidation (*1*).

If the oxidation of aldoses proceeds by a mechanism involving the free aldehyde form, it might be possible to find conditions where the formation of the free aldehyde from the hemi-acetal ring would be the rate-determining step. As ribose presumably has considerable free aldehyde in solution and mannose very little free aldehyde, an increase in the chlorite concentration might be expected to change the value of the rate

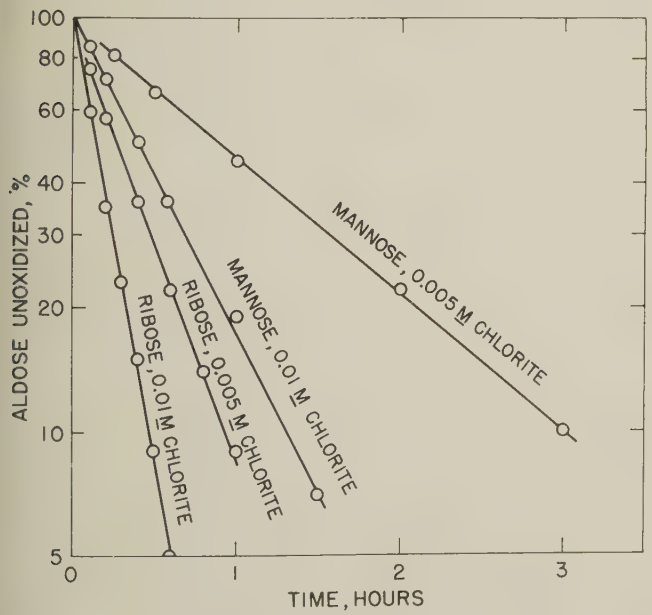

Fig. 3. Reaction of 0.25 millimolar mannose and ribose with 0.01 M and 0.005 M sodium chlorite buffered to pH 3.52 at 40°C.; determination of order with respect to aldose by the integration method

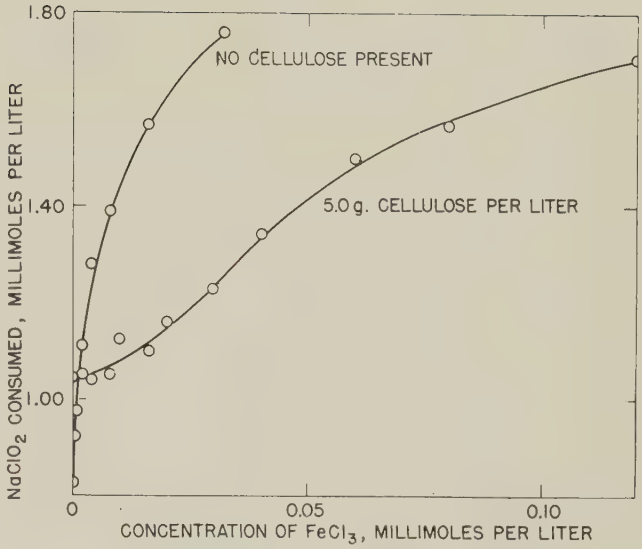
NaClO2 CONSUMED, MILLIMOLES PER LITER
CONCENTRATION OF FeCl3, MILLIMOLES PER LITER
NO CELLULOSE PRESENT
5.0 g. CELLULOSE PER LITER

Fig. 4. Decomposition of 0.005 M sodium chlorite buffered to pH 3.5 at 40° as a function of Fe^{+++} concentration. Time = 18 hr. in absence of cellulose; 19 hr. in presence of cellulose

constant for mannose but not for ribose. As shown in Table I, doubling the chlorite concentration did not appreciably affect the value of either rate constant. Semi-log plots of the data are given in Fig. 3. If the reaction involves the oxidation of the free aldehyde, the formation of the free aldehyde is not the rate-determining step under these experimental conditions.

The reactions of chlorite with aldehydes are not simple. Data obtained with isobutyraldehyde (*8*) indicate that the stoichiometry of the reaction, which occurs many times faster than with any sugars reported in this paper, is dependent on the relative amounts of chlorite and aldehyde and on ionic strength. Further work with glucose (*9*) indicates that the rate of oxidation at pH 3.5 is dependent on the concentration of the particular acid present in the reaction medium.

DETERMINATION OF ALDEHYDE IN CELLULOSE BY MEANS OF SODIUM CHLORITE

Some problems in the determination of aldehyde in cellulose (*10*) have been considered in an earlier paper. In this paper some preliminary data are presented on the estimation of aldehyde in cellulose obtained by determining the consumption of sodium chlorite in an acidic medium.

Harris and co-workers (*11*), Davidson (*12*), Davidson and Nevell (*13*), Nabar and Padmanabhan (*14*), Meller (*15*), and others have determined aldehyde in modified cellulose by measuring the change in carboxyl resulting from oxidation with sodium chlorite. Kocher (*16*), who investigated the effect of chlorite solutions under conditions normally used in bleaching, found that no degradation occurs at pH 5 at 60°C. except in concentrated solutions of chlorite (60 grams per liter) after about 20 hr. Cellulose did not have any appreciable catalytic effect on the dismutation of chlorite under any of the experimental conditions which he used. Davidson (*12*) and Samuelson and Ramsel (*17*) reported that chlorine dioxide has no degrading effect on cellulose. Staudinger (*18*), however, found that chlorine dioxide decreased the D.P. (degree of polymerization) of native and mercerized cotton. Lepeze and Dardelet (*19*) reported considerable decrease in

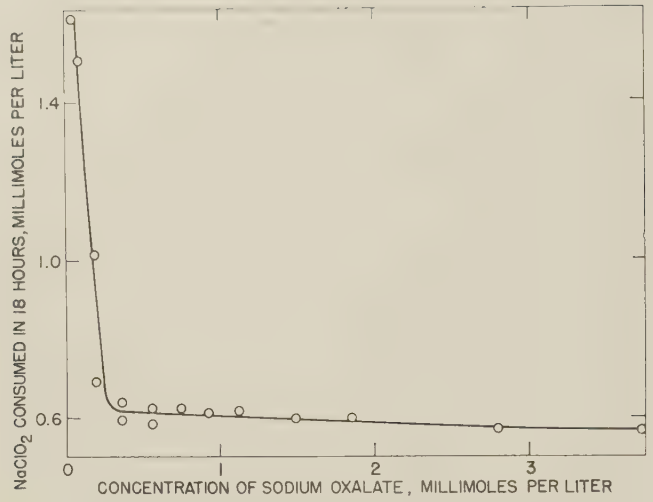

Fig. 5. Decomposition of 0.005 M sodium chlorite buffered to pH 3.52 at 40°C. as a function of oxalate concentration in the presence of 0.03 millimolar $FeCl_3$

D.P. when cellulose is treated with either chlorite or chlorine dioxide at pH 2, but found no change at pH 5.

Data obtained in connection with the present investigation indicate that the change in D.P. under the experimental conditions discussed in this paper, due to chlorite and chlorine dioxide, was negligible.

Cellulose Studied and Methods of Analysis

The experimental conditions for the reaction of sodium chlorite with modified celluloses were essentially the same as those used with aldoses.

As the reaction under study is heterogeneous, experiments were carried out to determine whether agitation was necessary. Although there were isolated instances which made agitation appear desirable, the data taken as a group indicated that it was unnecessary.

As the present work on the development of the chlorite method was undertaken originally to study the degradation of paper, several papers were included that were made in the semicommercial mill at the National Bureau of Standards. In addition several hydrocelluloses and periodate oxycelluloses prepared from purified cotton were studied.

The hydrocelluloses were prepared from purified cotton according to the directions given by Geiger and Wissler (*20*) with the exception of one which was prepared by hydrolyzing purified cotton to its leveling-off D.P. by the procedure recommended by Battista (*21*).

The periodate oxycelluloses were prepared by treating purified cotton with 0.029 *N* periodic acid, buffered to pH 4.6 with sodium acetate, at 25°C. The ratio of weight of solution to weight of cotton was 50. This procedure was recommended by Harris and co-workers

Table IV. Effect of Acid Pretreatment on the Carboxyl Content of Cellulose as Determined by Methylene Blue

Treatment	Carboxyl, millimole per gram of cellulose: Soda pulp	Carboxyl, millimole per gram of cellulose: Paper made from used, bleached cotton
Soaked in two changes of 0.1 *N* HCl for 1 to 2 hr. each, washed with 0.1 *N* HCl and then with H_2O	0.059	0.018
Washed with H_2O only	0.059	0.017

Table V. Effect of Prolonged Chlorite Treatment[a] on the D.P. of Cellulose

Sample	D.P. start	D.P. after 1 day	D.P. after 5 days	D.P. after 8 days
Soda pulp	375	370	370	380
Purified sulphite paper	1000	980	960	970
Paper made from used, bleached cotton	645	620	625	620
Paper made from unused, unbleached cotton	1490	1440	1400	1340

[a] 0.005 *M* chlorite buffered to pH 3.5 at 40°C.

(*11*). The consumption of periodic acid was determined by the method of Müller and Friedberger (*22*).

Degree of polymerization was calculated from cuprammonium viscosity data using the formula developed by Battista (*23*). Cuprammonium viscosity was determined by the method of Launer and Wilson (*24*).

Carboxyl content was determined with Davidson's modification of the methylene blue method (*25*). With this method it was reported that removal of the metal ions from the carboxyl groups with dilute acid before ion exchange with methylene blue was unnecessary. In order to check this point with our materials, carboxyl by the methylene blue method was determined on specimens of soda pulp and on a rag paper with and without acid washing. These celluloses probably represent the most unfavorable conditions for ion exchange that would be encountered by the methylene blue method, and the data in Table IV show conclusively that acid washing is unnecessary.

These data do not prove that all of the carboxyls are accessible to methylene blue, but they do show that if any carboxyls are covered by cations that are not removed by methylene blue, neither are they removed by dilute hydrochloric acid.

The only change made in Davidson's procedure was the use of 0.01 *N* hydrochloric acid instead of 0.1 *N* acetic acid to minimize the adsorption of methylene blue on glass during the photometric measurements. The concentrations of the methylene blue solutions were measured photometrically.

Effect of Prolonged Chlorite Treatment on D.P. of Cellulose

In order to determine whether sodium chlorite at

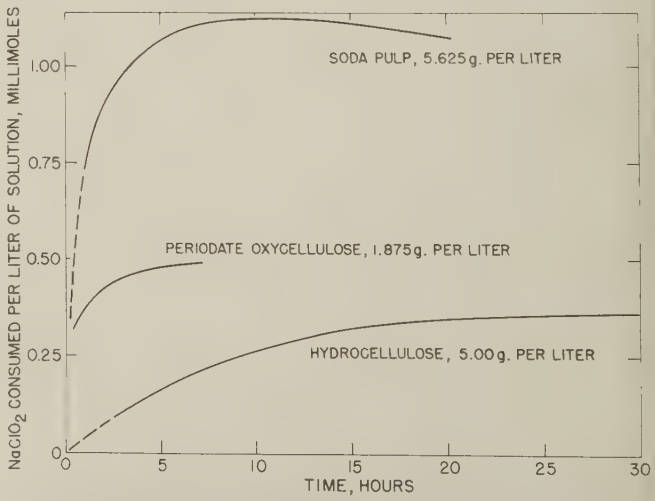

Fig. 6. Reaction of modified celluloses with 0.005 M sodium chlorite buffered to pH 3.52 at 40°C.

Table VI. Effect of Oxalate on the Reaction of Glucose with 0.005 *M* Sodium Chlorite Buffered to pH 3.52 at 40°C. for 18 Hr.

	Chlorite consumed, millimoles per liter	*Control minus test solution, millimoles per liter*
No oxalate added		
Control	0.758	
0.25 millimolar glucose	1.405	0.647
Solutions about 1.7 millimolar in sodium oxalate		
Control	0.590	
0.25 millimolar glucose	1.230	0.640

pH 3.5 degrades cellulose appreciably under the conditions described in this paper, several cellulose samples were treated with sodium chlorite, and D.P. determinations were made at intervals up to eight days. The specimens were washed thoroughly with water after the chlorite treatment, then briefly with concentrated ammonium hydroxide and added to the cuprammonium solution without drying. The data given in Table V show that 0.005 *M* $NaClO_2$ buffered to pH 3.5 at 40° does not degrade cellulose to an appreciable extent in 8 days (less than 10%).

Effect of Ferric Ions on the Decomposition of Acidic Chlorite Solutions

Lack of reproducibility of analytical data led to a systematic study of the effect of various metal ions that might be present in the reagents or in cellulose, on the catalytic decomposition of acidic chlorite solutions. It was found that ferric ions cause considerable catalytic decomposition.

Since ferric ions are very strongly absorbed by cellulose, it is to be expected that the effect of added iron on the catalytic dismutation of chlorite would be much less in the presence of cellulose than in its absence. The data plotted in Fig. 4 show this to be the case. In the absence of cellulose, 0.01 millimole of ferric ions per liter caused a 75% increase (0.625 millimole of chlorite per liter) in the dismutation reaction at 18 hr. while this amount of ferric ions, in the presence of cellulose, caused a very small increase in the decomposition. Corrections were made for the iodine liberated in the reaction of ferric iron with potassium iodide.

As it is desirable to avoid washing cellulose to remove iron before determining aldehyde, an oxalate salt was added to form a complex with the iron and to prevent catalysis. Oxalate was found to be more efficient for this purpose than citrate or tartrate salts. Figure 5 is a plot of the extent of dismutation at 18 hr. of a chlorite solution, 0.03 millimolar in ferric chloride, against oxalate content. The sharp break between 0.25 and 0.50 millimolar oxalate indicates that, for this particular system, the ratio of moles of oxalate to moles of iron for efficient complexing is at least 15. Although 0.03 millimole of ferric ions per liter is more than one would expect as an impurity in the reagents and samples, 0.93 millimolar oxalate (5 mg. per 40 ml.) was arbitrarily selected to provide an ample safety margin.

Other cations had a negligible catalytic effect, but manganous ion and oxalate as a pair exhibited the very interesting property of greatly decreasing the amount of dismutation of chlorite in acid solution. Unfortunately, the oxidizing power of chlorite toward aldoses was also decreased.

The effect of oxalate on the oxidation of glucose is shown in Table VI. The data indicate that there is no significant difference between the millimoles of chlorite used in the oxidation of glucose whether or not oxalate is present.

As shown in Table VII, there is a decrease in "oxidizable" material in the soda pulp of almost 10% in the presence of oxalate. No attempt is made here to interpret the chlorite consumed by the soda pulp in terms of aldehyde content.

Effect of Chlorine Dioxide

Chlorine dioxide is produced in both the decomposition and oxidation reactions. It was thought that this chlorine dioxide might affect the rates of these reactions, and might hydrolyze or dismutate to give products, not removed by bubbling, capable of reacting with potassium iodide. White and co-workers found that acidic chlorite solutions decompose much more rapidly if the chlorine dioxide is continuously removed during the reaction (*26*). In the present work it was found that the addition of chlorine dioxide at the beginning of an experiment did not appreciably suppress either the decomposition of chlorite or the oxidation of glucose. Furthermore it was found that chlorine dioxide solutions of the strengths encountered in this work gave negligible quantities of decomposition products that liberated iodine from potassium iodide.

STOICHIOMETRY OF THE REACTION OF SODIUM CHLORITE WITH ALDEHYDE IN CELLULOSE

The stoichiometry of the reaction of sodium chlorite with glucose and cellobiose (*2*) and the pentoses and some other sugars has already been discussed for specific experimental conditions. The ratio of moles of chlorite to moles of aldose appears to be 3:1 for glucose and cellobiose, and 3.6:1 for galactose, mannose, rhamnose, glucoheptose, and the pentoses. For the same experimental conditions, the ratio is about 3.4:1 for butyraldehyde and the reaction is complete in 5 min. or less (*27*).

Anhydroaldose end groups could be expected to react with the same stoichiometry as the monomer units. Aldehyde in the 2, 3, and 6 positions of the anhydroglucose ring offers more difficulty, as it is harder to find model compounds of simple monomer units that could be considered comparable. However, this is

Table VII. Effect of Oxalate on the Reaction of Soda Pulp with 0.005 *M* Sodium Chlorite Buffered to pH 3.52 at 40°C. for 18 Hr.

	Chlorite consumed, millimoles per liter	*Control minus test solution, millimoles per liter*
No oxalate added		
Control	0.689	
Soda pulp, 5.00 grams per liter	1.744	1.055
Solutions 0.93 millimolar in sodium oxalate		
Control	0.573	
Soda pulp, 5.00 grams per liter	1.537	0.964

probably not serious, as the moles of chlorite per mole of aldehyde range from 3.4 to 3.6 for all the compounds studied, with the exception of glucose. The aldehyde in the 3 position could be expected to form a furanose hemi-acetal ring, as it is a part of an erythrose unit. The aldehyde in the 2 position, being a part of a glyoxal unit, has no chance of forming a hemi-acetal except with a neighboring chain. Although such a reaction has been suggested as a possibility (*28*), steric hindrance and restrictive movement of cellulose chains would suggest that the reaction is far from complete. One might expect, therefore, that the 3-aldehyde would react similarly in rate and stoichiometry to a sugar that reacts with chlorite at a high rate, and the 2-aldehyde to react like a short chain aldehyde that has no possibility of hemi-acetal formation. Evidence to support this contention is presented later. As there is no reagent known that produces aldehyde exclusively in the 6 position, no data are available on the reaction of sodium chlorite with this modification.

With the above information as a basis, the following procedure was used in calculating the aldehyde content of the various celluloses from the amount of chlorite consumed in the reaction:

(1) Hydrocelluloses, Rag Papers, and Purified Sulphite Papers: The glucose calibration curve was used (*2*). Although the formula $C_o/3[1 - (C_T/C_c)]$ would probably have been preferable (*2*), its use is much more tedious and not warranted for the present work. C_o is the initial chlorite concentration, and C_T and C_c are the final chlorite concentrations in the test solution and in the control, respectively. The factor 3 is the moles of chlorite required to react with 1 mole of glucose.

(2) Periodate Oxycelluloses: The chlorite consumed was calculated from the formula $C_o/3.5[1 - (C_T/C_c)]$ for part of the experiments and from the glucose calibration curve for the remainder. A calibration curve for xylose would have been preferable to the glucose calibration curve as xylose and periodate oxycellulose react with chlorite at similar rates. The factor 3.5 used to convert moles of chlorite to moles of aldehyde

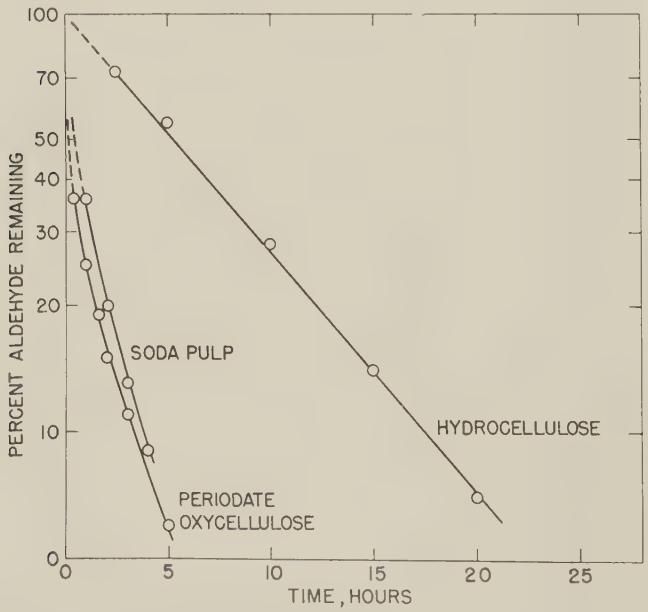

Fig. 7. Reaction of modified celluloses with 0.005 M sodium chlorite buffered to pH 3.52 at 40°C.; indication of order with respect to aldehyde by the integration method

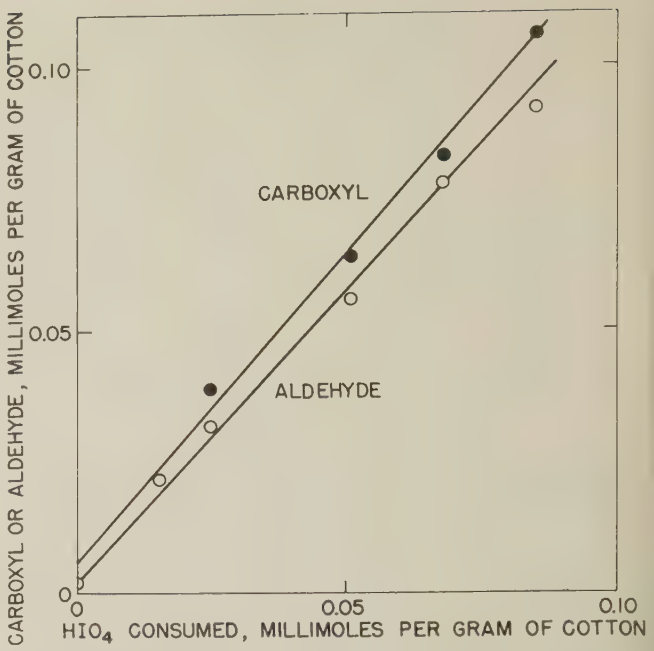

Fig. 8. Relation of consumption of periodate to aldehyde produced (measured by chlorite consumption) and to carboxyl produced by treatment with 0.005 M chlorite

is the average of 3.6 for the erythrose unit and 3.4 for the glyoxal unit. Aldehyde values taken from the glucose calibration curve were multiplied by 3.0/3.5 to allow for the probable difference in stoichiometry between glucose and the aldehyde in periodate oxycellulose in reaction with chlorite.

(3) Wood Pulp Papers: Cellulose derived from wood presents the additional problems of residual lignin, monomer units other than glucose, and the possibility of the presence of other oxidizable impurities. In addition, the cooking and bleaching operations modify the cellulose, the kind and extent of modification depending on the particular cooking and bleaching operations.

The data that are given later on wood cellulose indicate that only a small part of the chlorite consumption can be attributed to aldehyde in the cellulose for the samples studied. The remainder of the chlorite is probably consumed by the residual lignin. Therefore, any factor for converting moles of chlorite to moles of aldehyde is purely arbitrary, although the factor 3.5 is used here, and the result must be considered only as an "apparent" aldehyde value.

TIME-CONCENTRATION DATA ON MODIFIED CELLULOSES

Time-concentration plots for a hydrocellulose, a periodate oxycellulose, and a soda pulp are given in Fig. 6. These plots were obtained by subtracting a control curve from a test solution curve as already described for aldoses. Semi-log time plots for the same data are given in Fig. 7.

The plot for hydrocellulose in Fig. 6 indicates a reaction with only one type of compound, and this is borne out by the straight line for hydrocellulose in Fig. 7. The curves for soda pulp and the periodate oxycellulose in Fig. 6 both indicate a fast reaction with one substance and a slower reaction with another. This is also indicated by the plots in Fig. 7, assuming a first order reaction with each substance. Short chain aldehydes that contain no hydroxyl groups react

Table VIII. Aldehyde and Carboxyl Data on Hydrocelluloses Prepared from Purified Cotton

Treatment of purified cotton	Degree of polymerization	Aldehyde content per gram of cellulose: Calculated from D.P., millimole	Aldehyde content per gram of cellulose: Determined by chlorite consumption, millimole	Carboxyl content per gram of cellulose: Before chlorite treatment, millimole	Carboxyl content per gram of cellulose: After chlorite treatment, millimole	Carboxyl content per gram of cellulose: Change, millimole
None	2380	0.0026	0.0024	0.006	0.008	0.002
0.098 *N* HCl, 4 hr., 72°	775	0.008	0.005	0.006	0.010	0.004
0.098 *N* HCl, 9 hr., 72°	575	0.011	0.008	0.006	0.011	0.005
0.098 *N* HCl, 15 hr., 72°	490	0.013	0.010	0.005	0.013	0.008
0.098 *N* HCl, 24 hr., 72°	400	0.015	0.012	0.005	0.014	0.009
0.475 *N* HCl, 7 hr., 72°	360	0.017	0.014	0.005	0.017	0.012
2.5 *N* HCl, boiled 15 min.	200	0.031	0.028	0.005	0.026	0.021

with chlorite very rapidly (*27*); erythrose, extrapolating from data on other aldoses, should react more slowly, and glucose reacts most slowly of all sugars studied. One would expect the hydrocellulose plot to reflect the oxidation of glucose end groups and the periodate oxycellulose plot to reflect the rapid oxidation of the aldehyde in the 2 position as well as a slower reaction of the aldehyde in the 3 position. This appears to be borne out by the data.

The plots for soda pulp are similar to the plots for periodate oxycellulose. Although the cooking and bleaching operations may produce oxycellulose, the presence of residual lignin prevents the interpretation of the data in terms of type of modified cellulose.

ALDEHYDE AND CARBOXYL DATA ON VARIOUS CELLULOSES

Several periodate oxycelluloses were prepared by treating purified cotton with 0.029 *M* periodic acid at pH 4.6 at 25°C. for varying lengths of time. The amount of periodic acid consumed is of questionable value as a measure of the aldehyde content of the oxycellulose because of the peculiar adsorption effect noted by Harris and co-workers (*11*), and because of possible side reactions (*29*, *30*). Theoretically, the consumption of 1 milliequivalent of periodic acid should produce 1 millimole of aldehyde. Davidson and Nevell (*13*) prepared periodate-chlorite oxycelluloses by first reacting cotton with potassium metaperiodate and oxidizing the product with excess chlorite in acetic acid solution. They found that about 1 mole of carboxyl was produced for each gram atom of oxygen consumed by the cotton. The data plotted in Fig. 8 indicate that about the same relationship holds here for aldehyde produced by periodate treatment, and also for change in carboxyl resulting from treatment of the oxycellulose with 0.005 *M* chlorite.

Aldehyde and carboxyl data on several hydrocelluloses prepared from purified cotton are given in Table VIII. The aldehyde content, as determined by chlorite consumption, and the increases in carboxyl due to treatment with 0.005 *M* chlorite show fair agreement. Aldehyde values calculated from D.P. data also agree well with aldehyde values determined by the chlorite consumption. Aldehyde values from D.P. data are used here only as a rough check on the chlorite method, and it is not suggested that accurate aldehyde values can be calculated from D.P. data, or D.P. from aldehyde, although the latter has frequently been attempted.

Data on the aldehyde and carboxyl content of various papers are given in Table IX. Values for aldehyde content obtained from chlorite consumption do not correspond to the change in carboxyl upon chlorite treatment, the aldehyde values being consistently higher than the changes in carboxyl. The analytical values for the cotton rag papers are too small to be significant. The differences shown by the celluloses derived from wood are significant and can probably be attributed to the reaction of chlorite with residual lignin. For pulps that have been carefully bleached to prevent oxycellulose formation, it might be possible to develop a method in which the amount of chlorite consumed could be used as a measure of the lignin content.

CONCLUSIONS

The data presented in this paper suggest that the chlorite consumed by cellulose in 0.005 *M* chlorite solution buffered to pH 3.5 at 40°C. can be considered an approximate measure of the aldehyde content. The chlorite consumption has been related to carboxyl increase for periodate oxycelluloses and for hydrocelluloses, and it is probable that the same relationship holds for other modified celluloses, but this will require further investigation.

It has not been proved that maximum aldehyde values are obtained. In searching for experimental conditions of oxidation of cellulose with acidic chlorite solutions that would give a maximum carboxyl change, Davidson (*12*) used higher chlorite concentrations and longer reaction times than reported in this paper.

Table IX. Aldehyde and Carboxyl Data on Papers

Kind of papermaking fiber	Degree of polymerization	Aldehyde[a] content per gram of cellulose from chlorite consumption, millimole	Carboxyl content per gram of cellulose: Before chlorite treatment, millimole	Carboxyl content per gram of cellulose: After chlorite treatment, millimole	Carboxyl content per gram of cellulose: Change, millimole
Unused, unbleached cotton	1660	0.004	0.004	0.006	0.002
Unused, bleached cotton	695	0.009	0.013	0.016	0.003
Used bleached cotton	575	0.010	0.017	0.021	0.004
Purified sulphite	1195	0.010	0.021	0.026	0.005
Ordinary sulphite	645	0.035	0.030	0.050	0.020
Soda-sulphite	....	0.043	0.050	0.069	0.019
Soda pulp	375	0.065	0.050	0.071	0.021

[a] These are "apparent" aldehyde values. See text.

Therefore, the values reported here are probably low.

The determination of aldehyde by measuring the increase in carboxyl due to chlorite treatment has the advantage over the method described in this paper of presenting no complications regarding fractional and variable stoichiometric relationships. Also, several chlorite treatments may be used to bring about a maximum increase in carboxyl which, presumably, represents oxidation of aldehyde.

The use of chlorite consumption to measure aldehyde content of cellulose has the advantage of determining aldehyde in water-soluble fractions.

Further work is necessary in order quantitatively to determine the aldehyde content of cellulose from chlorite consumption, and this work is in progress, but the information given in this paper should be useful for obtaining approximate values.

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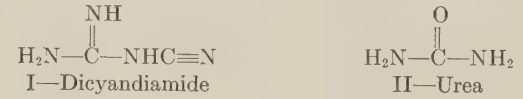
Use of Dicyandiamide in Paper Coatings

D. D. RITSON and C. G. LANDES

The use of dicyandiamide in adhesives and in print paper and fire retardant coatings is presented.

Dicyandiamide, a nitrogen compound obtained from calcium cyanamide, has been an article of commerce for some time. First prepared about 100 years ago, it has been used in the past primarily as an intermediate in the preparation of melamine, barbituric acid, and guanidine salts (*1*).

The formula for dicyandiamide (or cyanoguanidine) that most readily explains the majority of its chemical reactions is shown below (I), together with that of urea (II) which is quite similar.



I—Dicyandiamide

II—Urea

Dicyandiamide⊕, or "dicy" as it is commonly called, is a colorless, crystalline, non-hygroscopic and non-volatile material with relatively high melting point (209°C.). It is amphoteric in nature and has greater solubility in warm water (20 grams per 100 grams at 62°C.) than in cold water (3.5 grams per 100 grams a 20°C.). The solutions are approximately neutral and also show some buffering action (*1*).

Dicy is completely stable when dry, as well as in neutral aqueous solutions up to temperatures of 80°C., and for short periods of time up to 150°C. (*1*). It is relatively non-toxic having an oral LD_{50} for mice of about 12 grams per kg. (*1*).

ADHESIVE APPLICATIONS

The use of materials such as urea, thiocyanates, and other additives for fluidifying or thinning starch and casein dispersions has been known for some time (*2*, *3*, *4*). More recently, dicy was found by Kunze and Evans to be a very effective material for stabilizing the viscosity of starch adhesives (*5*). Later, dicy and various dicy derivatives were found by Studeny and Landes to be particularly good for reducing the viscosity and improving the stability of not only starch dispersions but also of many protein dispersions (*6*, *7*).

Dicy, when incorporated properly in aqueous starch or protein dispersions, has two principal effects: (1) reduction in the viscosity of the dispersion as made and, (2) stabilization of the dispersion such that gelling and other viscosity or fluidity changes upon aging are appreciably reduced or retarded. These effects are

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⊕ Sold to the paper industry under the designation AZITE® 900 Liquefier; refer to Technical Bulletin No. 21-A, American Cyanamid Co., Paper Chemicals Department.

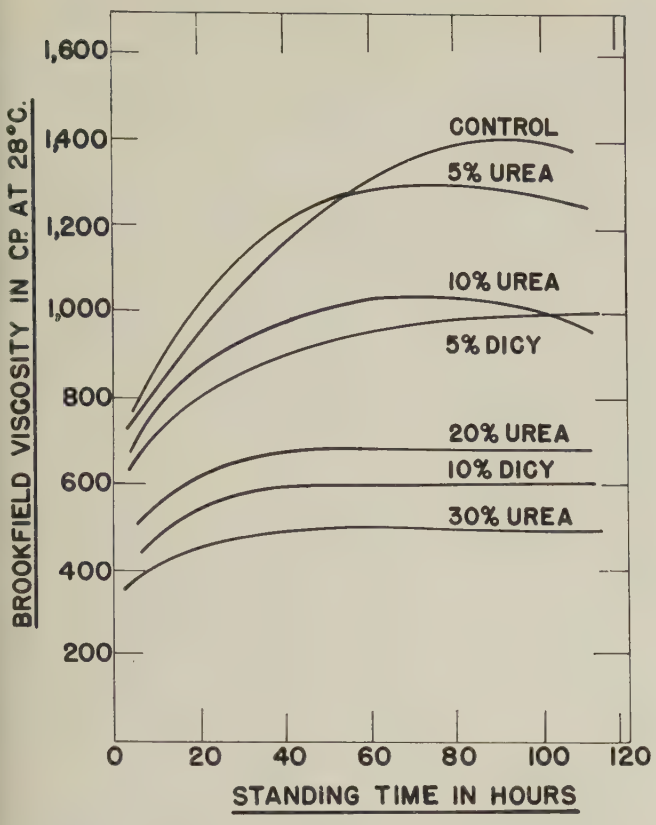

Fig. 1. Viscosities of 20% chlorinated starch dispersions modified with dicy or urea

quite important as they may lead to such advantages as higher solids content, longer working life, better adhesion and others. As shown below, dicy is much more effective than urea for these purposes.

The effect of different amounts of dicy compared with urea incorporated in a 20% (dry solids basis) chlorinated starch dispersion is shown in Fig. 1. The

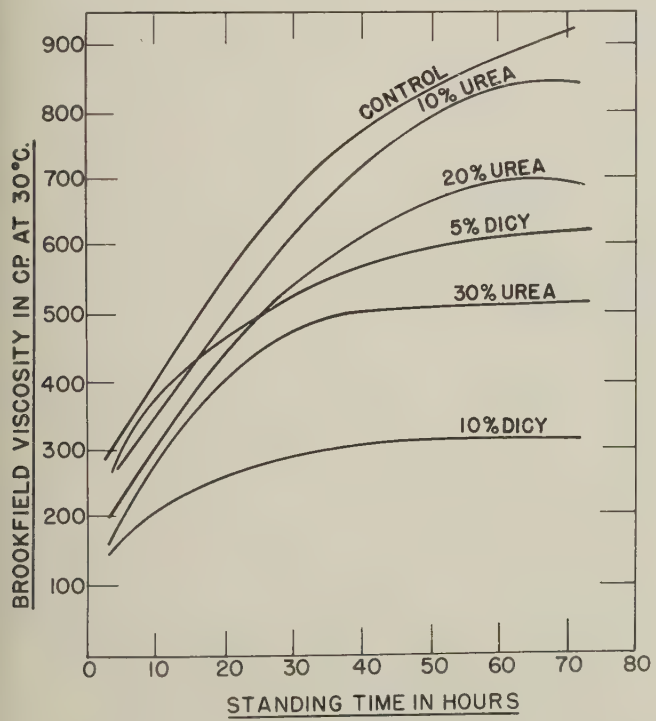

Fig. 2. Viscosities of 35% dextrin dispersions modified with dicy or urea

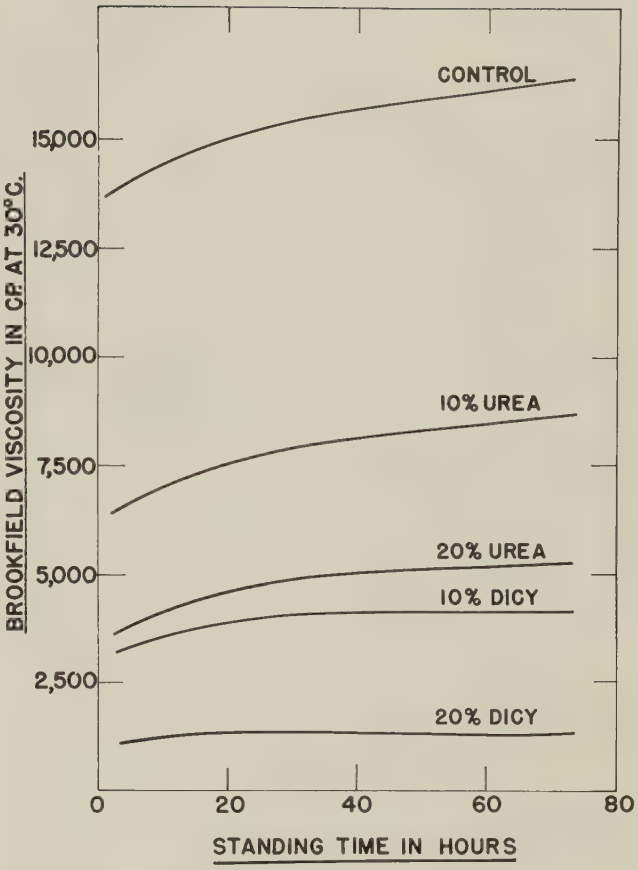

Fig. 3. Viscosities of 19% ammonia casein dispersions modified with dicy or urea

additives were incorporated in the starch-water slurry prior to cooking. Comparable conditions were used for heating, cooking (190°F.—15 min.), and cooling all of the formulations. Viscosities were determined using a Brookfield viscosimeter (60 r.p.m.) at 28°C. It should be noted that the starch solids was kept constant at 20% in all the formulations so in reality the total solids was greater, particularly with the higher percentages of additives.

Figure 2 shows the effect of incorporating the two additives in a 35% (dry solids basis) dextrin. The cooking and testing procedures were similar to those used for the chlorinated starch.

The comparative viscosity reducing effects of dicy and urea on an ammonia-cut casein dispersion are shown in Fig. 3. The casein used was a premium domestic grade and the additives were incorporated prior to the cooking process. Ammonium hydroxide (12% based on the dry casein) was used and the cooking temperature was 130°F.

The effect of higher proportions of dicy over longer periods of aging is shown in the next series of curves. Figure 4 shows the viscosities of 30% chlorinated starch dispersions in which amounts of dicy were added up to 25% based on the dry starch. The dicy was incorporated prior to cooking the starch at 190°F. for 15 min. Viscosities were determined (23°C.) using a Brookfield viscosimeter at 100 r.p.m. A small amount of a preservative (0.2% Dowicide G) was used in the adhesive to prevent spoilage over the long aging period of 480 hr.

The curves for 30% solids chlorinated starch (Fig. 4)

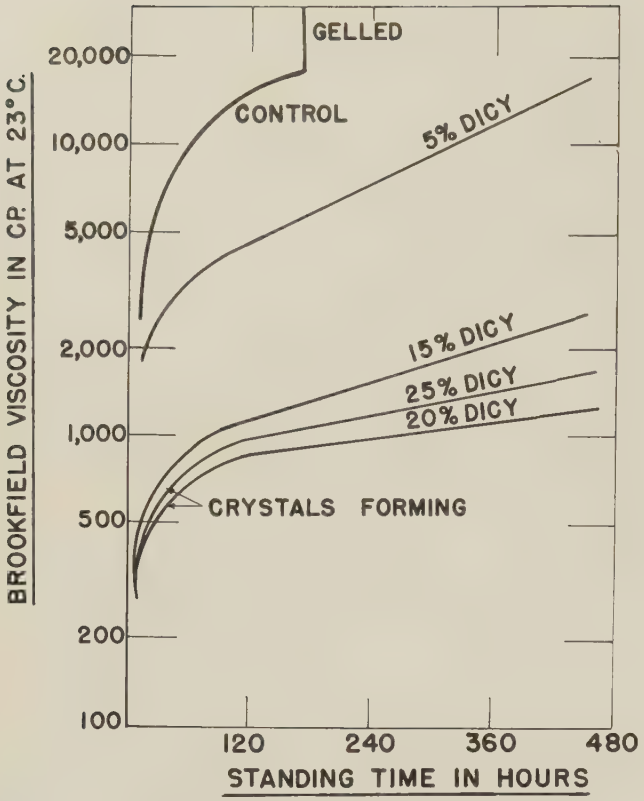

Fig. 4. Viscosities of 30% chlorinated starch dispersions modified with 0 to 25% dicy

show crystals forming at 20% dicy on the starch solids. It appears that 15% dicy on the starch solids is about the limiting solubility of dicy with this starch at this concentration (30%) and temperature (23°C.).

A similar series of curves showing the effect of up to 25% dicy on the viscosity of an ammonia-cut casein adhesive is presented in Fig. 5. The dicy was added to the casein before cooking. Ammonium hydroxide (12% based on the dry casein) was used and the cooking temperature was approximately 130°F. The amount of casein was kept constant in the formulations being 18% on a dry basis. A small amount of preservative (1.0% Dowicide B) was used to prevent spoilage over the long aging time. Viscosity was determined at 100 r.p.m. and 23°C.

PRINT PAPER COATINGS

The use of dicy in starch-clay coatings assists in reducing coating color viscosity and in improving the stability. By such use a higher solids coating color can be obtained which is important for machine coating applications. The viscosities of several starch-clay coating formulations containing various proportions of dicy to the starch are shown in Fig. 6. In all cases chlorinated starch was cooked for 15 min. at 190°F. Where dicy was used, it was added prior to cooking. The cooked starches were blended with domestic coating clay (25% dry starch on weight of dry clay) in typical coating formulations.

When using dicy in high solids applications, care should be taken that the amount used is not greater than its solubility limit, otherwise graininess of the coating can occur. It is preferred to cook the dicy with the starch prior to incorporation of the pigment. Most consistent results are obtained with converted starches such as the oxidized or chlorinated types. Use of dicy with enzyme-converted starch should be checked carefully, as in some instances no benefit is derived and occasionally even opposite results are obtained.

Casein-clay coatings also show a very appreciable viscosity reduction when dicy is cooked with the casein. Casein-clay coatings generally exhibit much higher viscosities than starch-clay coatings at the same solids, and in certain instances this fact has hindered their use in on-machine coating applications. By the use of dicy, it is possible to employ casein more readily in high solids, on-machine coatings. Other coatings such as soya protein-clay coatings and glue-pigment coatings show similar viscosity improvement with dicy present.

Shown in Fig. 7 is a comparison of a casein-clay coating at two different solids with increasing amounts of dicy. The casein coating was prepared using 15% casein (cut with soda ash and borax) on the clay.

During the past few years dicy has been used commercially in increasing quantities for both starch and protein pigment coatings. This trend has been particularly evident in machine coating where an increase in solids content is of great importance. Better flow properties and application of the coating with less pattern effect have been observed in some cases.

Other beneficial effects have often been obtained by the use of dicy in starch and protein adhesives or coatings. For example, the use of dicy appears to enhance the preservative effect of ordinary preservatives such as the chlorinated phenols. Indications of better pigment dispersion have been noted. In starch cooking a

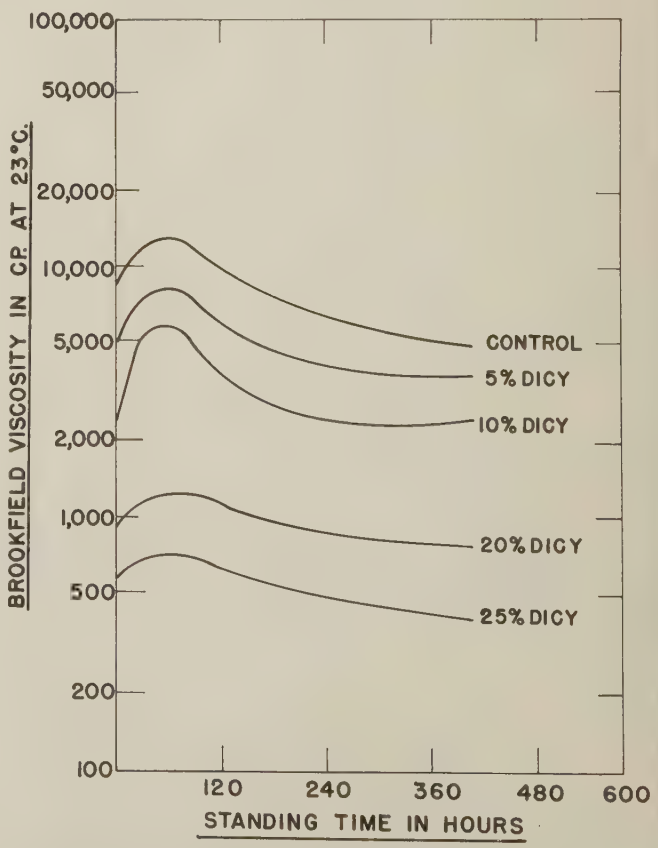

Fig. 5. Viscosities of 18% ammonia casein dispersions modified with 0 to 25% dicy

reduction in the temperature of gelation has been observed.

The mechanism by which dicy reduces the viscosity of starch and protein dispersions, and improves their stability, has not been investigated in detail. The effect certainly is not unique to a single type of compound, although many nitrogen compounds such as the amides have shown fluidifying properties. One possibility is that hydrogen bonding is modified as suggested by Sullivan (*8*).

FIRE RETARDANT COATINGS

Fire retardant coatings for insulating board, accoustical tile, and wallboard have been of increasing interest in recent years. This trend will probably continue due to stricter fire regulations in building codes and increased public interest in fire prevention. One of the products finding application for this purpose is dicyandiamide. In the intumescent-type coating it has been found to give improved fire retardancy, increased intumescence, and reduced char area.

Methods of incorporation of dicy in these coatings are as varied as the different types of formulations. Several patents on the use of this and similar products for fire retardancy have appeared recently. In general, the formulations consist of a starch or carbohydrate material, a resin (usually melamine-formaldehyde or urea-formaldehyde), an acid salt, pigments, and dicyandiamide (*9,10*). The use of dicy with vinyl chloride-vinylindine chloride latices has been suggested (*11*). Cooking dicy with the carbohydrate component of the

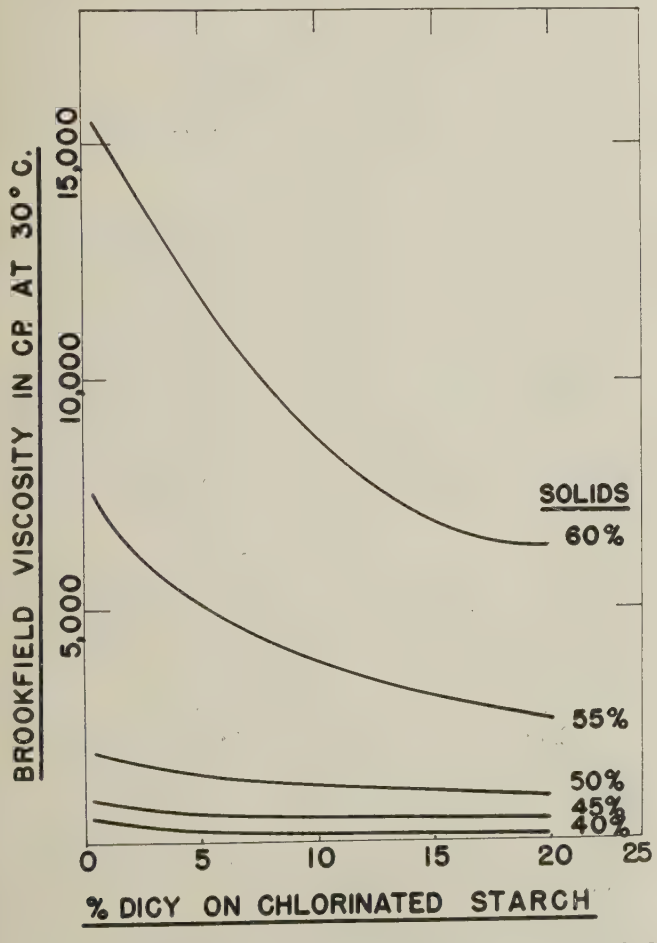

Fig. 6. Viscosities of starch clay coating colors modified with 0 to 20% dicy

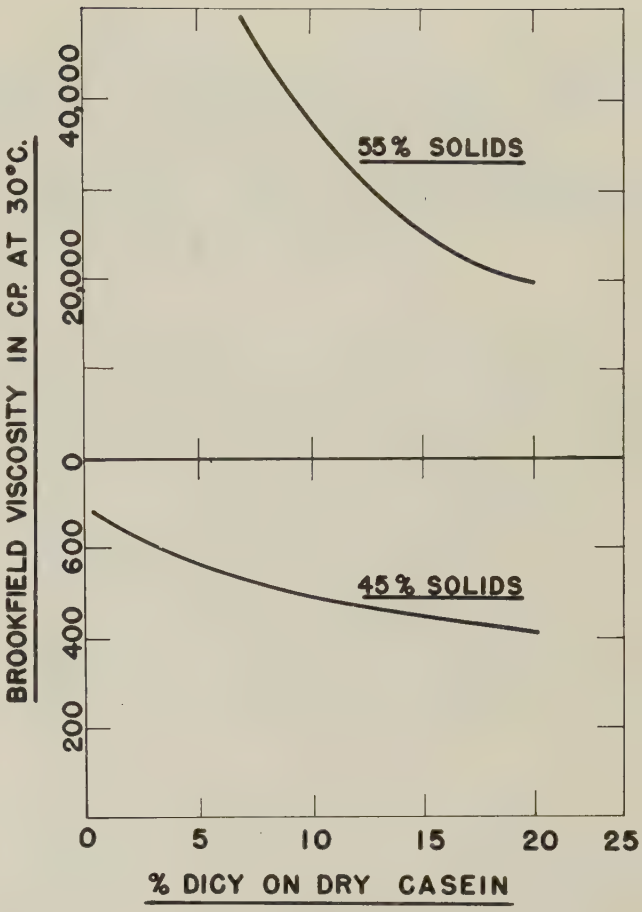

Fig. 7. Viscosities of casein clay coating colors modified with 0 to 20% dicy

formulation has been found suitable in some instances. Where large amounts of dicy are to be incorporated in the formulation, it may be preferred to regard it as a pigment and add it as a finely ground material. Another procedure is to react dicy with formaldehyde before incorporating it in the coating (*12*).

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The Interrelationship of Fiber Length Distribution, Fiber Length Index, and Physical Characteristics of Handsheets

A. H. NADELMAN, R. SCHMUT, D. J. KRASKE, and R. I. LARSON

A study of fiber length index, fiber length distribution, fiber classification, and the strength of handsheets made from fiber fractions at various levels of beating, shows that fiber length index provides a sensitive measure of mechanical effort expended on pulp in the early stages of beating, while fiber classification may be used to follow beating on slow stock when fiber length index and freeness no longer serve as sensitive guides. It is also shown that the strength of handsheets made from fractions obtained by screen analysis seems to reach a relatively constant value after an initial beating period, although the strength of handsheets made from the whole pulp changes progressively with prolonged beating. The fractions obtained by screen classification also are shown to have averages and ranges of fiber length which are independent of the degrees of beating.

THIS paper represents a combination of the efforts of three senior students in the Curriculum of Paper Technology at Western Michigan College in Kalamazoo, Mich. The degree granting course is on an undergraduate level; therefore, the major connection with problems of theoretical nature is the special assignments given senior students for independent study under the direction of the faculty. Although papers of this type are seldom released for publication, the work of three students was found to be of general interest, and it was felt that the work should be combined and published as a contribution to the knowledge of the practical significance of fiber length and fiber length distribution.

The initial investigation was undertaken by R. Schmut during the academic year 1951–1952. This early work was followed by more detailed projects carried out by D. J. Kraske and R. I. Larson during the academic year of 1952–1953.

The initial work consisted of a study of the effect of beating of pulp and its influence on fiber fractions obtained in a Bauer-McNett fiber classifier (*1–4*). Handsheets were formed from the whole pump and from the fractions obtained at different degrees of beating. The physical characteristics of the handsheets were determined. In the more detailed study fractions were produced in a similar way using different combinations of screens. Again, the physical properties of handsheets were determined. Concurrent with this study was another detailed survey which involved use of the fiber length classification grid plate (*5*), as well as a microscopic projection method for determination of the exact fiber length distribution by weight and by number within the various classified fractions previously mentioned.

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OBJECTIVES

Since a survey of the literature indicated that many publications deal with the effect of beating on fiber length distribution (*1, 6–9*) and reveal much information on technique of fiber length classification (*10, 11*) this work was organized to correlate the following four factors: (1) fiber length distribution of an unbeaten and beaten pulp, (2) fiber length distribution of several fractions of the same pulp, (3) fiber length distribution of unbeaten and beaten pulp retained on the fiber length classification grid plate, and (4) physical characteristics of handsheets formed from unbeaten and beaten pulp before and after fiber fractionation.

Since a great variety of pulps have been compared with each other concerning the shifting of fiber length distribution on beating (*12*), this study is limited in its main body to an investigation of one single pulp and the four factors previously mentioned.

EXPERIMENTAL DESIGN

The initial investigation consisted of a series of beater runs using a commercial pulp processed according to the standard method of the Technical Association of the Pulp and Paper Industry (*13*).

The unbeaten pulp and subsequent samples representing successive 10-min. beating intervals were fractionated in a Bauer-McNett fiber classifier. In addition to the use of the screen analysis method, samples of the unbeaten and beaten pulp were tested by means of a fiber length classification grid plate.

Standard handsheets (*14*) were formed from the complete pulp at each degree of beating, and also from the significant fractions obtained. These handsheets were studied to determine the bursting strength, tensile strength, tearing resistance, and M.I.T. folding endurance (*15*).

During the succeeding academic year, further refinements were made in the methods used in the initial experimentation. These included preparation of a detailed study of the fiber length of the various fractions obtained.

The final experimental design was as follows:

1. Experimental work was confined to a bleached coniferous sulphate pulp, obtained from the West Coast of the United States.

2. Characteristics of this pulp were determined by making a beater run according to TAPPI standard procedures.

3. Samples of the pulps were then treated in the same beater to levels of approximately 750, 600, 500, 400, 300, and 200 ml., Canadian Standard freeness (*16*).

4. Samples at each freeness were fractionated on a Bauer-McNett fiber classifier. Fractions were taken with screens of 10, 16, 20, 35 mesh, and the effluent was drained through a 200-mesh screen to retain

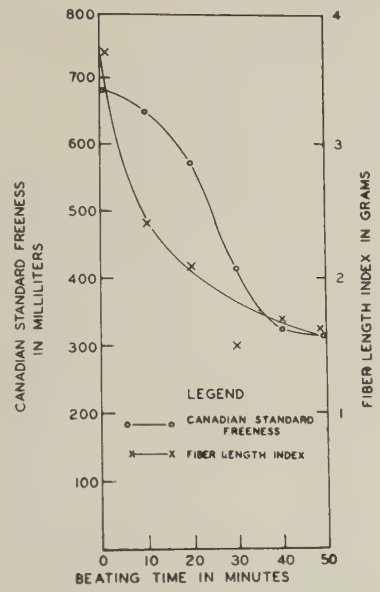

Fig. 1. Beating time versus freeness and fiber length index (Scandinavian bleached kraft)

"usable fines." Ten-gram quantities of pulp were used in the classifier with a 30 min. running time for each sample. In each case, the 16 and 20-mesh portions were mixed and refractionated over a series of screens including 16, 20, 35, and 65 mesh, again collecting the very small quantity of "usable fines" on a 200-mesh screen.

5. Handsheets were made from fractions collected on 10, 16, 20, and 200-mesh screens. In all cases,

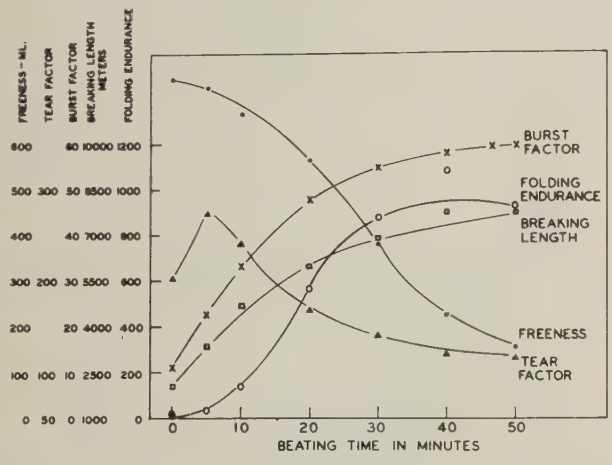

Fig. 2. Beater evaluation of bleached west coast kraft.

fractions collected on other screens were found to be insufficient for the formation of handsheets.

6. Samples of the whole pulp at each level of beating were used for tests on the fiber length classification grid plate.

7. The fiber length distribution and the average fiber lengths were determined for the fractions and for the fiber retained on the classification grid plate.

8. The handsheets formed were conditioned at 73°F. and 50% R.H. before testing for the following characteristics: basis weight, caliper, apparent density (by calculation), bursting strength, tearing resistance, tensile strength, and folding endurance.

The following method was used in the determination of fiber length and fiber length distribution (*6, 10, 17, 18*): Fibrous suspensions were agitated and diluted

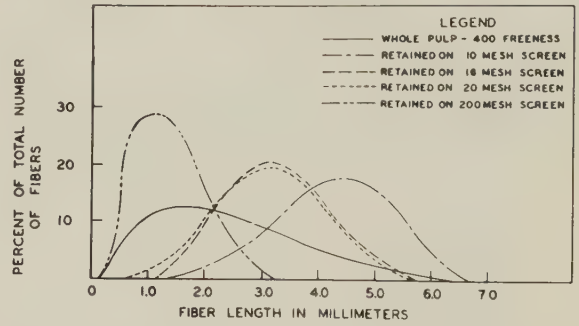
LEGEND
WHOLE PULP - 400 FREENESS
RETAINED ON 10 MESH SCREEN
RETAINED ON 16 MESH SCREEN
RETAINED ON 20 MESH SCREEN
RETAINED ON 200 MESH SCREEN
PERCENT OF TOTAL NUMBER OF FIBERS
FIBER LENGTH IN MILLIMETERS

Fig. 3. Distribution curves. Groups arranged in 0.5 mm. intervals

Per cent of total number of fibers versus fiber length interval.

so that 1 drop of the suspension contained approximately 10 to 20 fibers. Six drops of the suspension were withdrawn and transferred to a microscope slide, using a 6-in. length of 4-ml. glass tubing fitted with a rubber dropping bulb.

The slides were moved to a hot plate with a controlled surface temperature of 70°C. Immediately upon placing the slides on the hot plate, the slides were tapped with a dissecting needle and 1 drop of 0.5% solution of locust bean gum was added (*19, 20*). The addition of this gum resulted in uniform distribution of fibers on the slide. Following drying, 2 drops of C stain were applied and a cover glass was placed over the fibers. After 1 min. the excess stain was removed from the slide before projecting the image. This was done by means of a Bausch and Lomb triple-purpose microprojector, calibrated so that 1 mm. distance on the slide coincided with 2 in. on the screen. The images of the fibers were measured with a Keuffel and Esser

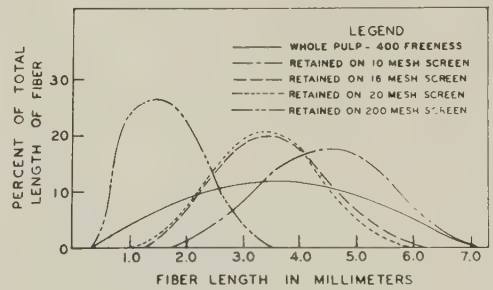
LEGEND
WHOLE PULP - 400 FREENESS
RETAINED ON 10 MESH SCREEN
RETAINED ON 16 MESH SCREEN
RETAINED ON 20 MESH SCREEN
RETAINED ON 200 MESH SCREEN
PERCENT OF TOTAL LENGTH OF FIBER
FIBER LENGTH IN MILLIMETERS

Fig. 4. Distribution curves. Groups arranged in 0.5 mm. intervals

Per cent of total length of fiber versus fiber length interval.

map measurer. The lengths of all fibers were recorded on a fiber length frequency chart. An example of such a chart is shown as Table I. An average of 100 fibers was measured in each fraction. All whole fibers, broken

fibers, and fiber fragments larger than 0.25 mm. were measured and recorded.

Numerical and weighted average fiber lengths were computed, using the method described by Reed and Clark (*20*).

EXPERIMENTAL RESULTS

Experimental results in this work may be divided into two parts, one covering the work done in the 1951–1952 period, and one covering results obtained during the 1952–1953 academic year. Completion of the earlier work showed that screens for the Bauer-McNett classifier must be carefully selected to give an adequate separation over the range natural to a given pulp. Evaluation of handsheets formed from fractions gave a clear indication that bursting strength, tensile strength, and folding endurance of the component fractions did not equal or exceed the strength shown by the whole pulp at any given degree of bearing; however, the long fibered fraction of the pulp was superior in tearing resistance to the whole pulp and to shorter fractions of the pulp.

Table I. Method of Classifying Fiber Length Observations

Freeness—400 ml. Fraction retained on 20 mesh screen

FIBER LENGTH RANGE IN MM.	FIBER COUNT	MEAN OF RANGE	NUMBER OF FIBERS	TOTAL LENGTH	CUMULATIVE LENGTH
0.25 – 0.50		0.38	0	0	0
0.51 – 0.75	I	0.63	1	0.63	0.63
0.76 – 1.00		0.88	0	0	0.63
1.01 – 1.25		1.13	0	0	0.63
1.26 – 1.50	II	1.38	2	2.76	3.39
1.51 – 1.75	卌	1.63	5	8.15	11.54
1.76 – 2.00	III	1.88	3	5.64	17.18
2.01 – 2.25	卌 II	2.13	7	14.91	32.09
2.26 – 2.50	卌 IIII	2.38	9	21.42	53.51
2.51 – 2.75	卌 I	2.63	6	15.78	69.29
2.76 – 3.00	卌 卌 卌	2.88	15	43.20	112.49
3.01 – 3.25	卌 卌 II	3.13	12	37.60	150.09
3.26 – 3.50	卌 卌 卌 I	3.38	16	54.10	204.19
3.51 – 3.75	卌 卌	3.63	10	36.30	240.49
3.76 – 4.00	卌 IIII	3.88	9	34.90	275.39
4.01 – 4.25	卌 IIII	4.13	9	37.20	312.59
4.26 – 4.50	IIII	4.38	4	17.52	330.11
4.51 – 4.75	IIII	4.63	4	18.52	348.63
4.76 – 5.00	I	4.88	1	4.88	353.51
5.01 – 5.25	I	5.13	1	5.13	358.64
5.26 – 5.50	II	5.38	2	10.76	369.40
5.51 – 5.75		5.63	0	0	369.40
5.76 – 6.00		5.88	0	0	369.40
6.01 – 6.25	I	6.13	1	6.13	375.53
TOTAL NUMBER OF FIBERS MEASURED ----- 117 RANGE OF DISTRIBUTION ----- 1.25 – 5.50 MM.					

Table II. Summary of Fiber Length Distribution Data

IDENTIFICATION OF SAMPLE		COUNT OF FIBERS IN GROUPS (MEASUREMENTS IN MILLIMETERS)	TOTAL COUNT
FREENESS 750	WHOLE PULP	3 4 13 6 11 9 3 6 4 5 11 4 7 6 8 4 7 5 7 1 5 0 1 0 1 0 0	133
	RETAINED-10 MESH	0 0 0 3 1 1 1 0 0 0 5 2 6 7 9 12 11 8 9 7 6 8 6 4 0 0 1	106
	" 16 "	0 0 1 0 0 0 4 4 4 6 10 7 9 8 8 7 9 4 11 4 5 0 1 1 0 0 1	84
	" 20 "	1 0 0 0 4 2 4 5 15 13 12 9 8 6 7 7 4 0 3 3 1 1 0 0 0 0 0	105
	" 200 "	10 9 18 13 10 5 3 1 2 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	73
FREENESS 600	WHOLE PULP	2 3 10 7 9 7 11 6 9 2 9 5 2 4 2 3 9 2 1 3 1 0 1 1 1 0 0	110
	RETAINED-10 MESH	0 0 0 1 2 2 2 1 2 4 6 7 9 7 9 5 13 6 11 8 3 3 3 0 1 0 0	104
	" 16 "	0 2 3 3 6 2 5 2 8 8 10 13 10 7 13 7 8 1 1 2 1 1 0 1 1 0 0	115
	" 20 "	0 0 3 2 0 2 6 6 13 12 12 13 3 4 4 7 3 3 0 0 1 0 0 0 0 0 0	100
	" 200 "	1 1 2 1 7 1 2 7 9 6 3 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	79
FREENESS 500	WHOLE PULP	8 8 9 5 9 7 9 5 5 2 4 1 7 11 6 8 2 3 5 1 2 1 4 1 0 0 0	121
	RETAINED-10 MESH	0 0 0 0 0 0 0 0 1 4 5 8 9 5 15 16 12 11 9 10 2 3 5 5 1 2	122
	" 16 "	0 0 0 0 2 4 6 9 17 12 13 12 5 8 13 10 3 7 8 3 2 1 0 0 0 0 0	135
	" 20 "	0 0 0 0 10 10 19 15 14 12 8 9 9 5 5 2 1 1 1 0 0 0 0 0 0 0 0	121
	" 200 "	10 16 19 15 12 16 8 3 3 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	104
FREENESS 400	WHOLE PULP	4 5 14 9 4 5 9 8 8 4 6 9 3 4 6 3 6 3 7 3 1 3 1 1 1 0 1	126
	RETAINED-10 MESH	0 0 0 2 0 1 0 2 4 2 5 5 5 12 15 11 6 9 11 10 8 5 3 2 3 1 0	122
	" 16 "	0 0 0 1 0 1 2 6 8 9 11 6 13 9 11 7 4 3 4 1 2 1 0 0 0 0 0	99
	" 20 "	0 1 0 0 2 5 3 7 9 6 15 12 16 10 9 9 4 4 1 1 2 1 0 0 0 0 0	117
	" 200 "	3 10 14 19 7 6 10 6 2 3 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	81
FREENESS 300	WHOLE PULP	3 10 8 3 7 10 7 8 12 12 5 7 12 5 4 2 5 2 3 2 0 0 1 2 0 0 0	130
	RETAINED-10 MESH	0 0 0 1 2 1 0 3 3 2 2 5 7 15 15 13 9 10 1 6 7 4 10 3 1 0 0	130
	" 16 "	0 0 0 0 0 0 3 6 7 11 13 8 11 11 14 8 6 5 6 6 6 4 4 1 2 0 1	122
	" 20 "	0 0 0 0 1 5 11 16 20 9 10 10 13 8 9 1 8 3 1 4 2 0 0 0 0 0 0	131
	" 200 "	20 15 18 14 10 4 5 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	91
FREENESS 200	WHOLE PULP	10 11 13 12 5 4 9 5 7 7 4 9 5 2 1 3 1 1 1 1 0 0 0 0 0 0 0	112
	RETAINED-10 MESH	0 0 0 2 0 1 0 0 1 6 5 6 9 9 18 9 8 6 1 6 8 3 0 2 1 0 0	101
	" 16 "	NONE RETAINED BY 16 MESH	
	" 20 "	0 0 0 1 0 8 6 7 17 8 13 12 10 5 7 5 5 2 2 1 2 0 0 0 0 0 0	111
	" 200 "	15 12 15 21 12 6 4 1 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	88
TOTAL = 3193			

A comparison of fiber length index figures and Canadian Standard freeness results as shown in Fig. 1 demonstrated a fundamental difference of the shape of the curves for freeness and fiber length index measurement. Canadian Standard freeness figures served to indicate major differences at intermediate periods of beating, while figures obtained with the classification grid plate approached the form of a parabola. This curve showed an appreciable effect in the initial stage of stock preparation with adequate response in the intermediate range and approximately the same low sensitivity as the Canadian Standard freeness method when the pulp reached a low degree of freeness.

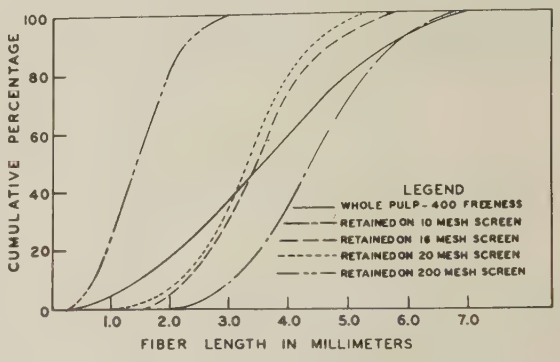

Fig. 5. Distribution curves. Groups arranged in 0.25 mm. intervals

Cumulative length per cent versus fiber length intervals.

During the second year of the investigation a strong, long-fibered pulp, with characteristics typical of sulphate pulps from Douglas-fir, was studied (*21*). Numerical average length of the pulp was 2.74 mm. More significantly, the weighted average fiber length of the unbeaten pulp was 3.56 mm. Individual fibers as long as 6.50 mm. were found in the pulp during a microscopic examination. A conventional strength development diagram of the pulp was prepared as shown in Fig. 2.

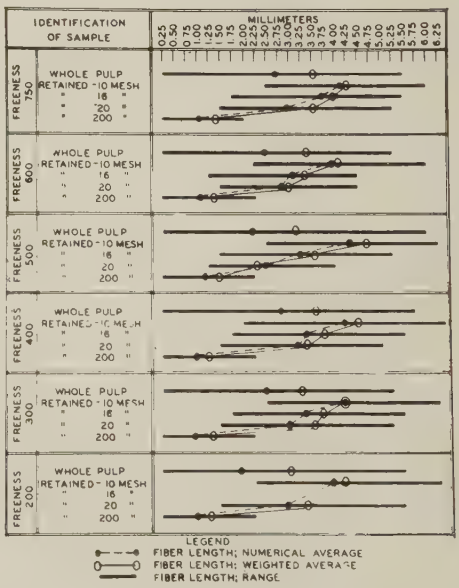

Fig. 6. Range of fiber length and average fiber length of fractions

A conventional strength development diagram of the pulp was prepared as shown in Fig. 2.

Skewed distribution curves showing fiber length distribution at 400-ml. Canadian Standard freeness are shown in Fig. 3 for the whole pulp and for the fractions obtained by screening. The extreme negative skewedness of the whole pulp curve, and the fraction retained on the 200-mesh screen, shows the unusual amount of bias which fines introduce into this method. As shown in Fig. 4 a weighted average based on per cent of total length shows a completely normal distribution for all samples except for those retained on the 200-mesh screens where a negative skewedness is still observed. This deviation from normal distribution is undoubtedly due to the decision to ignore all particles of fiber with no dimension greater than 0.25 mm.; this technique also has a slight influence on an analysis of the whole pulp. These effects are also demonstrated in Fig. 5 which shows cumulative fiber length distribution.

Table III. Summary of Average Fiber Length Data and Range of Fiber Length

IDENTIFICATION OF SAMPLE		AVERAGE FIBER LENGTH NUMERICAL AVERAGE MM.	AVERAGE FIBER LENGTH WEIGHTED AVERAGE M.M.	RANGE OF FIBER LENGTH MILLIMETERS
FREENESS 750	WHOLE PULP	2.74	3.58	0.25 – 5.50
	RETAINED-10 MESH	4.24	4.25	2.50 – 6.00
	" 16 "	3.78	4.00	1.75 – 5.50
	" 20 "	3.02	3.58	1.25 – 5.25
	" 200 "	1.10	1.48	0.25 – 2.00
FREENESS 600	WHOLE PULP	2.54	3.44	0.25 – 5.25
	RETAINED-10 MESH	3.98	4.08	2.25 – 6.00
	" 16 "	3.12	3.42	1.25 – 4.50
	" 20 "	2.82	3.01	1.50 – 4.50
	" 200 "	1.10	1.42	0.25 – 2.25
FREENESS 500	WHOLE PULP	2.26	3.19	0.25 – 6.00
	RETAINED-10 MESH	4.38	4.74	2.50 – 6.25
	" 16 "	3.28	3.60	1.50 – 5.25
	" 20 "	2.52	2.33	1.25 – 4.00
	" 200 "	1.20	1.52	0.25 – 2.25
FREENESS 400	WHOLE PULP	2.84	3.65	0.25 – 5.75
	RETAINED-10 MESH	4.23	4.52	2.00 – 6.50
	" 16 "	3.37	3.75	1.75 – 5.50
	" 20 "	3.21	3.36	1.50 – 5.00
	" 200 "	1.33	1.74	0.25 – 2.75
FREENESS 300	WHOLE PULP	2.51	3.30	0.25 – 5.25
	RETAINED-10 MESH	4.23	4.23	2.50 – 6.25
	" 16 "	3.54	4.07	2.00 – 5.50
	" 20 "	3.00	3.57	1.50 – 5.25
	" 200 "	0.98	1.36	0.25 – 2.25
FREENESS 200	WHOLE PULP	1.99	3.05	0.25 – 5.50
	RETAINED-10 MESH	3.98	4.24	2.25 – 6.25
	" 16 "			NO FIBERS RETAINED
	" 20 "	3.00	3.38	1.50 – 5.50
	" 200 "	1.04	1.32	0.25 – 2.25

The preceding three figures demonstrate the close similarity of the fibers retained on the 16 and 20-mesh screens. This similarity was noted throughout the work at all levels of beating.

Table IV. Changes in the Fiber Length Distribution and the Fiber Length Index

BEATING TIME	FREENESS CANADIAN STANDARD	FIBER LENGTH INDEX	PERCENT BY WEIGHT, BASED ON WHOLE PULP, RETAINED ON CLASSIFIER SCREENS					TOTAL WEIGHT ACCOUNTED FOR
MINUTES	MILLI-LITERS	GRAMS	10 MESH	16 MESH	20 MESH	35 MESH	200 MESH	PERCENT
0	750	5.65	57.5	0.1	23.7	4.4	13.3	92.7
15	570	3.33	57.7	1.0	23.2	4.6	13.5	97.0
19	500	3.00	54.7	1.1	25.7	5.0	13.5	89.5
24	395	2.67	40.8	1.2	37.3	5.2	15.5	87.0
28	300	2.40	38.9	1.1	39.4	5.0	15.6	90.0
33	200	2.14	28.4	2.4	43.8	7.7	17.7	84.5

Summaries of fiber length distributions at the various beating levels are presented in Table II. Averages and ranges are reported in Table III, and all these data are compiled and plotted in Fig. 6.

These results show that the numerical and weighted averages of fiber lengths retained on each screen remain in a very narrow range over the entire cycle of beating, showing that the screens in the classifier retain their ability to classify according to length, even though fibrillation and fines are greatly increased by mechanical action.

With exception of an unexplained deviation at 400-ml. freeness, a clear trend is shown for a steady decrease in average fiber length of the whole pulp during the beating cycle. Furthermore, the range of fiber length within a given fraction remains substantially constant throughout the treatment.

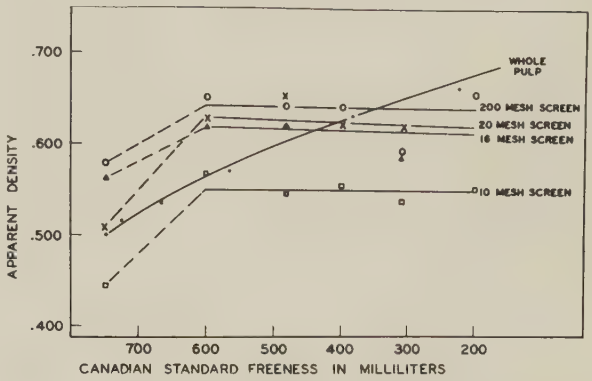

Fig. 7. Apparent densities of the various fractions

A comparison of weights retained on various screens, along with fiber length index figures, beating times, and freeness results is compiled in Table IV. Here are seen again the relationship between freeness and fiber length index as it was demonstrated in Fig. 1. It is also shown that the first 15 min. beating time made no effective change in the weight of fiber fractions retained on the various screens, although freeness dropped to the extent of 180 ml., and the most conspicuous change in fiber length index was shown. After this initial period, a relatively steady decrease in the long fraction was noted with increased mechanical action in the beater. There was, of course, a corresponding increase in the shorter fractions, and a general trend toward a larger loss through the 200-mesh screen used to retain "usable fines."

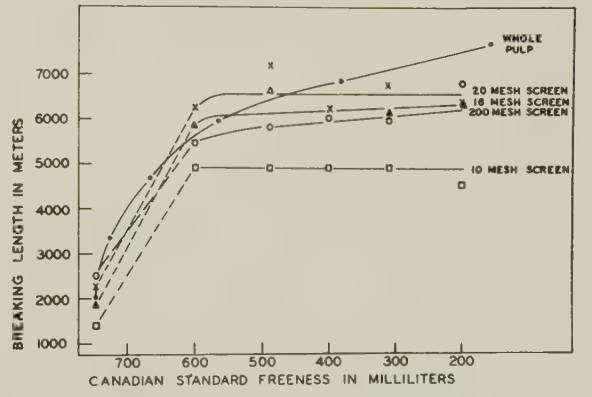

Fig. 8. Breaking lengths of the various fractions

Results of physical tests on handsheets are summarized in Tables V and VI. This includes apparent density, burst factor, breaking length, M.I.T. folding

endurance, numerical average fiber length, and Canadian Standard freeness.

The relationship of the density of the various fractions and the whole pulp at different levels of beating is shown in Fig. 7. In view of the work of Doughty (*22*), the fact must be emphasized that these handsheets were all pressed at one equal pressure for the same duration so that the density of the sheets was in no way

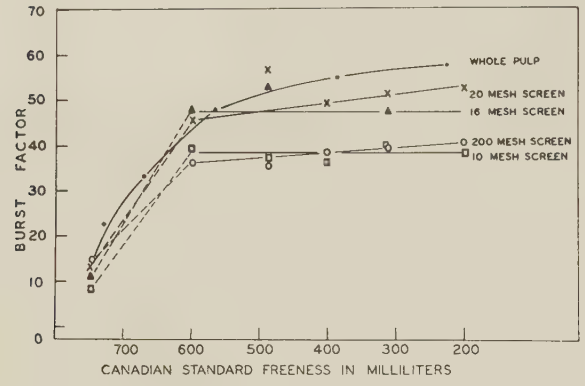

Fig. 9. Burst factors of the various fractions

"artificial." These results seem to indicate that the initial beating period had a pronounced effect on density within the individual fractions. After this time density within a given fraction remained substantially constant. Shifts in the density of sheets made from the whole pulp may be interpreted as being due to two factors, namely the change in the proportion of the various fractions, as well as the presence of those fines which, when fractionated, passed the 200-mesh screen.

Tensile strength, expressed as breaking length, is shown in Fig. 8 for the whole pulp and for four fractions of the pulp. In this case, it is again shown that in early stages, intermediate fractions may surpass the strength of the whole pulp; however, each fraction apparently reached a maximum value, possibly after the primary cell wall was ruptured and partially stripped from the fiber, and retained that value throughout additional beating. The whole pulp, a composite of the fractions, plus fines, again exceeded the contribution of any of the individual portions of the pulp. The same phenomenon is also shown when bursting strength is similarly plotted in Fig. 9.

Table V. Evaluation of Handsheets from Pulp before Fractionation

FREENESS ML. CANADIAN STD.	AVERAGE NUMERICAL FIBER LGTH.- MM.	BASIS WT. G/M²	APPARENT DENSITY	BURST FACTOR	TEAR FACTOR	BREAKING LENGTH METERS	M. I. T. FOLDING ENDURANCE
747	2.74	67.0	.498	12.5	193	2135	8
600	2.54	59.0	.595	46.5	151	6050	497
485	2.66	64.5	.648	49.5	142	6660	1015
400	2.84	65.5	.636	50.7	138	6790	1033
310	2.51	62.5	.651	56.1	129	6920	794
200	1.99	65.0	.712	60.2	110	7700	1268

Tearing resistance of the individual fractions, as compared with the tearing resistance of the whole pulp, also provides an interesting study as shown in Fig. 10. Here, fiber length was of obvious importance, as shown by the manner in which the tearing strength of the long fraction consistently exceeded the tearing strength of the whole pulp and all other fractions in order of decreasing length. Again, the behavior of the whole pulp was apparently a function of contribution

Table VI. Strength Characteristics of Handsheets from Various Fractions

FRACTION MESH	AVERAGE NUMERICAL FIBER LGTH.- MM.	RANGE OF FIBER LENGTHS MM.	FREENESS ML. CANADIAN STD.	APPARENT DENSITY	BURST FACTOR	TEAR FACTOR	BREAKING LENGTH METERS	M. I. T. FOLDING ENDURANCE
10	5.44	2.5 - 6.0	747	.444	8.25	195	1412	2
10	3.99	2.0 - 6.5	600	.568	39.2	282	4895	551
10	4.38	2.5 - 6.25	485	.546	37.5	291	4940	624
10	4.23	2.0 - 6.5	400	.555	36.5	293	4920	716
10	4.23	2.5 - 6.25	310	.538	39.4	325	4900	408
10	3.98	2.25-6.25	200	.552	37.8	304	4500	726
16	3.78	1.25-4.5	747	.562	11.4	178	1880	10
16	3.12	1.0 - 5.0	600	.620	47.6	154	5870	672
16	3.28	1.5 - 5.25	485	.622	52.7	151	6650	999
16	3.37	1.75-5.25	400		NO	YIELD		
16	3.54	2.0 - 5.5	310	.588	47.4	164	6100	503
16			200		NO	YIELD		
20	3.02	1.7 - 5.5	747	.507	14.2	240	2245	16
20	2.82	1.5 - 4.5	600	.631	45.7	133	6240	818
20	2.52	1.25-4.00	485	.654	56.7	99	7200	569
20	3.21	1.5 - 5.00	400	.624	49.6	137	6230	767
20	3.00	1.5 - 5.25	310	.620	51.2	153	6780	574
20	3.00	1.5 - 5.5	200	.648	52.5	133	6890	1222
200	1.1	0 - 2.5	747	.578	14.5	115	2535	14
200	1.1	0 - 2.5	600	.652	36.2	80	5490	171
200	1.2	0 - 2.25	485	.642	35.8	82	5800	179
200	1.3	0 - 2.75	400	.641	38.3	78	6010	194
200	1.0	0 - 2.1	310	.592	39.2	68	6070	153
200	1.04	0 - 2.25	200	.658	40.9	68	6820	733

of the various fractions according to their proportions and according to the fines not directly measured.

CONCLUSIONS

On the basis of the experimental data presented, the following conclusions may be drawn:

1. The fiber length index values, obtained by the use of the classification grid plate seem to have good sensitivity in the range of initial beating where freeness tests and results of screen classification appear to be relatively insensitive. Screen classification, on the other hand, appears to have maximum sensitivity and

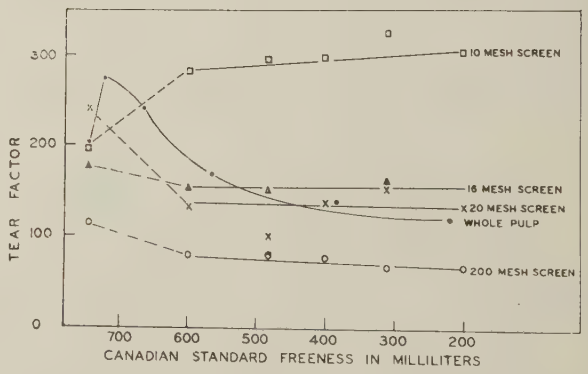

Fig. 10. Tear factors of the various fractions

usefulness in the evaluation of thoroughly beaten and slow stock where freeness and fiber length index no longer provide distinct differentiation.

2. Screen classification produces fractions which have rather definite averages and ranges of fiber length independent of the degree of beating. The amount of beating expresses itself in the classifier only by the quantity of fibers retained on each screen.

3. Although the physical characteristics of the whole pulp change progressively with prolonged beating, the strength properties of fractions obtained by screen analysis seems to reach a characteristic value after an initial beating period. These values for tearing strength, bursting strength, tensile strength, and density are apparently retained during additional mechanical work in the beater.

The density of all fractions, except the one containing the longest fibers, is greater than the density of the whole pulp during the early stages of beating. After characteristic maxima of density have been reached for each individual fraction, the density of the whole pulp exceeds that of the individual fractions.

Bursting strength and tensile strength both indicate similar situations. The intermediate fiber fractions exceed the strength of the whole pulp and both fractions containing the longest and shortest fibers during the initial stages of beating. In the final stages of beating the whole pulp is superior in strength to the level of any of the fractions.

The initial effect of beating on tearing strength of the fractions needs further investigation. In the final stages of beating, the tearing strength of the whole pulp decreases as the average fiber length decreases. In this stage of the beating cycle the tearing strength of the long and intermediate fractions is clearly higher than the tearing strength of the whole pulp, and only the shortest fraction is weaker in tearing resistance than the whole pulp.

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Evaluation of Acrylic Binders for Paper Coating Pigments by Study of Free Films

PAUL J. McLAUGHLIN

The present study is based on free pigmented films considerably more massive than those normally applied to paper. The factor of interaction with substrate is thus eliminated and the measured film strengths appear to be an inverse measure of binder requirement.

Performance of binders for paper-coating pigments depends principally on two factors: interaction of binder with pigment and adhesion of binder to substrate. It is customary to evaluate binder requirement of various pigments and concentrations of various binders required by a given pigment by measuring "wax pick" of coated paper or board. This property is undoubtedly a complex function of a number of factors including those mentioned above. In the case of thermoplastic binders, wax pick is unreliable as a measure of printing performance and the Scotch tape adhesion test, sometimes substituted, is unsatisfactory.

It seemed worth while to investigate the properties of free pigmented films considerably more massive than those usually applied to paper or board, because this procedure would eliminate one factor: interaction with the substrate. This would permit a more precise study of efficiency of pigment binding and selection of pigment and dispersant compositions for maximum coating strength. This paper presents preliminary work based on this approach and confined to Rhoplex AC-33 and related acrylic binders. It is believed, however, that examination of free films may be a broadly useful procedure.

PIGMENT-BINDING EFFICIENCY AS MEASURED BY TENSILE STRENGTH

Figure 1 shows tensile strengths of various paper

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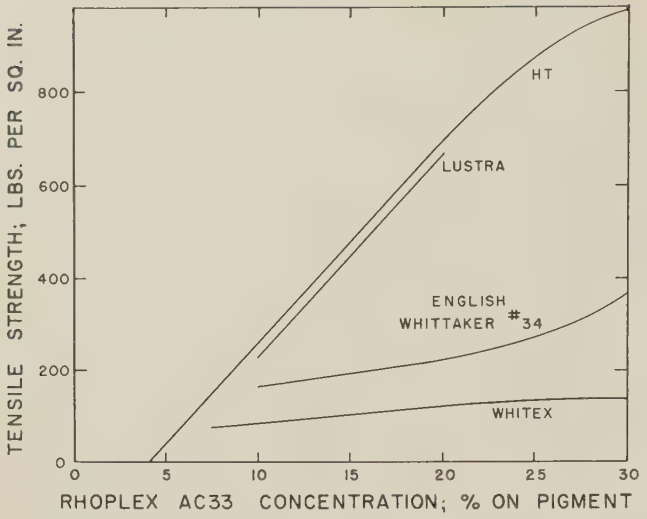

Fig. 1. Effect of binder concentration on tensile srtength of clay films

coating clays containing between 7.5 and 30% Rhoplex AC-33. In each case, the pigments were mixed with binder after dispersion at optimal dispersant concentration as indicated by viscosity measurement.

The resemblance of these curves to those relating Dennison wax number of coated paper and binder content given by Casey (*1*) and by Hughes and Roderick (*2*) will be noted at once. This would confirm that coating strength is a dominant factor in printing behavior.

One might be led to conclude that binder levels of around 10% used with typical clays, such as Edgar Brothers HT, would be adequate for preparation of coatings of satisfactory performance. Indeed, this is probably the case for well-sized raw stocks where sufficient anchoring has occurred without excessive penetration of binder and consequent weakening of the coating. For open papers, or low-grade board, however, where penetration is extensive, higher levels of binder will probably be required. Evidence bearing on this effect based on wet-rub resistance will be discussed below.

Figure 2 shows similar curves for calcium carbonate and titanium dioxide pigments approaching the sperical shape, with that for HT clay, included for comparison. Using the strength of the film based on fine particle carbonate (Purecal M: 0.2 mu) as 1, HT clay has a relative strength of 5, rutile (Titanox RA), 1.5, and Snowflake whiting (2 mu calcium carbonate), 3. It appears valid, as a first approximation, to use tensile strengths at a given binder level (say 10%) as an inverse measure of binder requirement. Strengths clearly depend not only on particle size, but also on shape, the lamellar clay pigments being inherently stronger.

Table I. Effect of Substrate on Coating Strength
Lustra Clay-Rhoplex AC-33 films

Per cent on pigment					
Calgon	*Rhoplex AC-33*	*Viscosity, cp.*[b]	*Wet rub, 8-mil film on:*[a] *Glass*	*Paper*	*Board*
0.3	10	340	8.8	10.0	21.5
	20	390	4.8	5.0	6.5
0.2	10	290	7.8	10.0	13.5
	20	270	4.5	4.8	6.0

[a] Films were 20 mils caliper wet, 8 mils dry on glass. Values for wet rub are based on reflectance of residue on black paper: complete resistance would give a reading of 3.5.
[b] Brookfield viscosity (12 r.p.m., spindle no. 2); 60% total solids.

Table II. Effect of Thickness on Coating Strength
10% Rhoplex AC-33 films

Clay type	*Total solids, %*	*Viscosity, cp.*[a]	*Film strength*[b]*, p.s.i. 10 mils*	*20 mils*	*40 mils*
Lustra	60	340	330	225	220
English (no. 34 Whittaker)	50	1290	260	166	..
Whitex (calcined)	50	20	120	100	..

[a] Brookfield, 12 r.p.m., spindle no. 2. In each composition, 0.3% Calgon on pigment was used.
[b] Corresponding dry calipers were as follows for Lustra: 3.2, 9.0, and 21.0 mils.

There are, however, other factors which must modify conclusions based on film strengths before these can be applied to board or paper coating behavior. In addition to the factor of binder penetration, there is also an effect of binder-pigment stratification dependent principally on viscosity and not peculiar to acrylic-bound coatings. This will also be discussed below.

EFFECT OF DISPERSANT TYPE AND LEVEL ON COATING STRENGTH

Figure 3 compares films of rutile titanium (Titanox RA) dispersed with a polyphosphate dispersant and with Tamol 731, and shows the effect on strength of change in dispersant type. Judging by viscosities at all binder levels, this rutile is less aggregated in Tamol 731 dispersion. Formation of coherent films at 7.5% AC-33 or somewhat lower is thus permitted. Polyphosphate-dispersed films require 10% binder. However, the slope of the strength-binder concentration curve is steeper for the poorer dispersant. This suggests that the relatively more aggregated rutile-polyphosphate system requires less binder for cohesion after the effect of incomplete dispersion is overcome (above 16% AC-33).

EFFECT OF SUBSTRATE ON COATING STRENGTH: WET-RUB RESISTANCE

The magnitude of the effect of raw stock on coating strength may be judged from the data of Table I where identical coatings on glass (free films), well-sized paper, and board are compared. Wet-rub resistance was chosen as a convenient test.

Penetration of binder into the relatively open board has caused definitely poorer wet-rub behavior compared

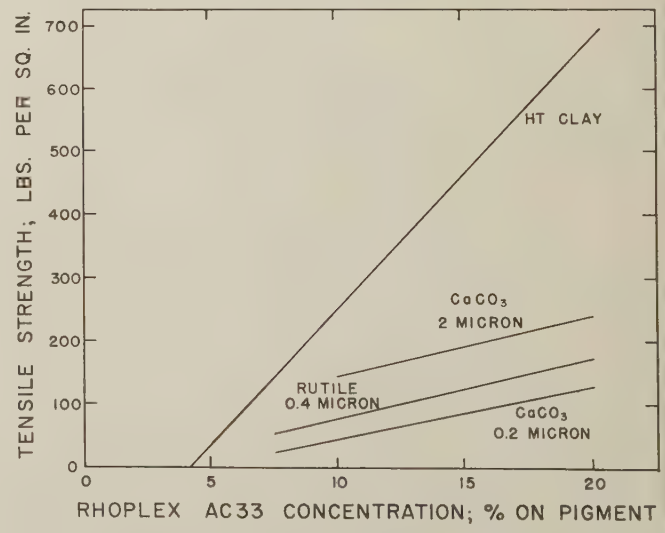

Fig. 2. Effect of binder concentration on tensile strength of calcium carbonate and titanium oxide films

Table III. HT Clay-Experimental Acrylic Compositions. Free Film and Coated Paper Stiffness

Acrylic[a] designation	Approx. softening point, °C.	Free film properties[b] Tensile strength, p.s.i.	Free film properties[b] Stiffness, Gurley, mg.	Calendered coated paper, Gurley stiffness, mg.
A	18	250	165	60
B	30	555	500	83
C	35	410	1530	84
D	36	200	1330	79

[a] Experimental acrylic binders, all used at 10% on clay with 0.3% Calgon on clay.
[b] Sixty per cent total solids compositions cast as 20-mil films and dried at 150°C. (see Experimental Section).

with paper, and the values for paper coatings were somewhat inferior to those for glass.

In the case of a porous raw stock this effect of drainage of binder is undoubtedly dominant. On well-sized paper and especially at heavy coating weights, another factor, stratification of binder and pigment becomes important also. On a nonporous substrate like glass, this stratification becomes the exclusive process. It actually has the beneficial effect of increasing wet-rub resistance.

SEPARATION OF PIGMENT FROM BINDER: FILM STRENGTH AS A FUNCTION OF THICKNESS

Pigment-binder separation is illustrated in Table II. Films of 10, 20, and 40 mils wet thickness were dried down on glass. Under these exaggerated conditions, the settling process occurred over very much longer times and settling depths than obtain in paper or board coating practice. Stratification is indicated by decreasing tensile strength as film thickness is increased, the thinnest films (about 3 mils dry) giving the greatest strengths.

It was noted that the thicker films showed higher wet-rub resistance probably because the acrylic content of the surface had been enriched.

In a particular case, a 40-mil film of calcined clay Whitex-Rhoplex AC-33 prepared with 7.5% binder on pigment (7.0% AC-33 on coating) was analyzed for binder. Scrapings from the top contained approximately 17.7% acrylic; the bottom of the film contained only about 3.7%.

It is possible that the wet-rub improvement effected by addition of low levels of English clay to board coating mixture (*3*) is due in part to increased settling of this type. It is difficult to associate the good wet rub

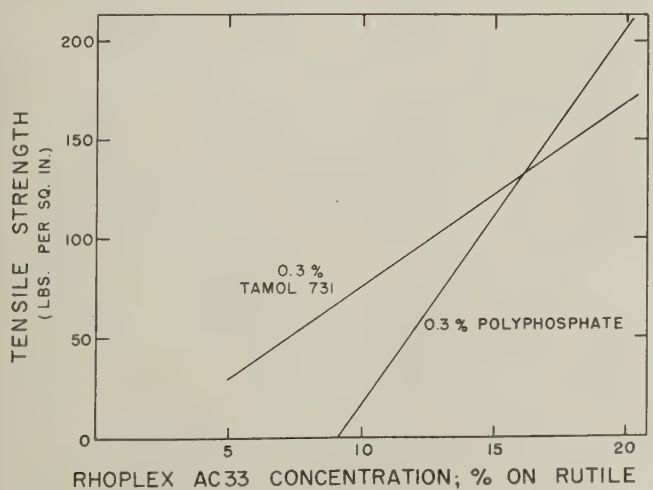

Fig. 3. Effect of dispersant type on film strength

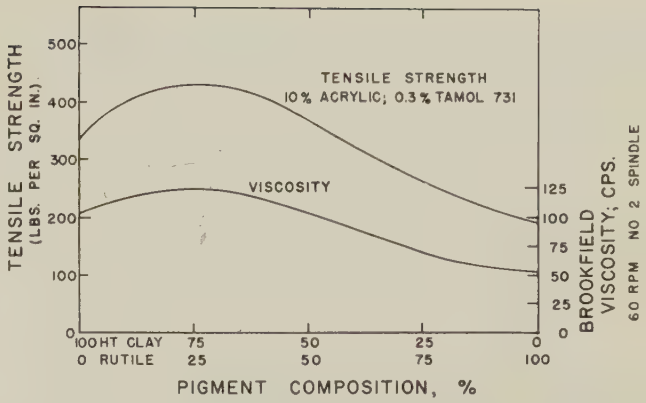

Fig. 4. Effect of pigment composition on film strength

resistance of English clay with any unique chemical or structural features.

EFFECT OF PIGMENT COMPOSITION ON FILM STRENGTH

Figure 4 shows results of experiments based on an experimental acrylic binder and a clay-rutile system. The dispersant used (Tamol 731) is considerably more active for this particular rutile than for clay. This appears to result in a competition of pigments for dispersant resulting in the maximum in the viscosity-composition curve. This maximum coincides with a similar maximum in the tensile strength curve suggesting that at maximum viscosity least separation of binder from pigment occurs. Stated differently, the binder demand of a 75 clay:25 rutile composition is less than those of either component. This conclusion is similar to that drawn by Roderick and Hughes (*4*) for clay-precipitated calcium carbonate mixtures.

ACRYLIC BINDERS OF VARYING HARDNESS: MEASUREMENT OF FREE FILM STIFFNESS

Gurley stiffness measurements on coated papers depend largely on paper stiffness since substrate constitutes so large a portion of the test specimen. Table III indicates that stiffness measurements on free films provide a more sensitive guide for improvements in binder stiffness. Results are independent of raw stock stiffness. It is believed that free film stiffnesses correlate better with subjective qualities such as "rattle" in corresponding coated papers based on the same raw stock.

Table III is based largely on experimental acrylics and the coated paper properties are all for laboratory "drawdowns."

EXPERIMENTAL

Coatings were prepared (usually at 60% total solids) on a 200 to 600 gram scale by addition of binder to the dispersed pigment with stirring. A laboratory Lightnin' mixer or Waring Blendor was used. Clay coatings were brought to pH 8 to 9 by addition of about 0.1% NaOH before addition of acrylic. Films were prepared on glass plates by means of a Filmograph, then allowed to air dry. After drying they were immersed in water and the loosened films then easily lifted. The free films were then allowed to dry on strong paper. Tensile strips, usually $^1/_2$ by 4-in. were cut and tested on Scott IP-2 or IP-4 tensile testers. Usually, six measurements were made and averaged.

Caliper of the individual strips was measured and used in computing tensile strength in pounds per square inch. It is estimated that the strengths used in the curves are precise to ±10% of the value given.

In the case of the harder acrylics of Table III, drying was done at 150°C. in a draft oven in nearly all cases. It was found that continuous films could also be prepared at temperatures at least as low as 75°C. Gurley stiffness was measured on 1/2 by 1-in. films, and the values are considered to have a precision of ±7%.

CONCLUSIONS

Study of free binder-pigment films may provide useful qualitative and semiquantitative information about binder performance in coating of paper or board. Work to establish the correlation with mill experience on the one hand, and with acrylic binder composition on the other is continuing. Meanwhile, the preliminary results appear sufficiently interesting to justify the suggestion that free film studies may be generally useful.

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3. Schucker, F. L., private communication.
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Study of Drier Bearings

L. A. MOORE

The data presented indicate some of the reasons for drier bearing troubles with a cautionary note that they should not be used directly, but rather as a basis in the study of a particular installation. The effects of the lubricant and the operating temperature on the amperage load are considered. Plain bearing performance is compared with that of an antifriction bearing.

SEVERAL years ago the Electrical Committee of the Engineering Division of TAPPI reviewed and revised the power constants for paper machine drives. Among these were factors relative to drier drive constants. It is the purpose of this paper to throw a little light on the variables which govern these factors. It is apparent that the plain drier bearing, as designed and used for years, has without question been expected to meet present-day demands. This, unfortunately, is an error. All known drier steam pressures in the beginning were low, say 5 to 10 p.s.i. Machines designed to operate at 15 lb. are now being operated at 35 to 50 lb.

The following figures will indicate some of the reasons behind present-day plain drier bearing troubles. The data given should not be used for all cases, but as a background for a plan of study for each specific case.

All plain bearings have basically the same characteristics. The coefficient of friction is influenced by the viscosity of the oil, the speed of the journal, and the unit pressure. For a given combination of operating materials, such as a cast iron journal running in a bronze bushing, a curve as indicated in Fig. 1 can be established from actual test data. The viscosity of the oil Z is in centipoises, the speed N is in revolutions per minute, and the unit pressure P is in pounds per square inch projected area.

Area 1 is the operating range of proper lubrication where a journal is running on oil. Area 2 has bearing to journal contact with partial lubrication. Area 3 has metal to metal contact. For this study P will be considered as a constant since specific cases are cited in each comparison.

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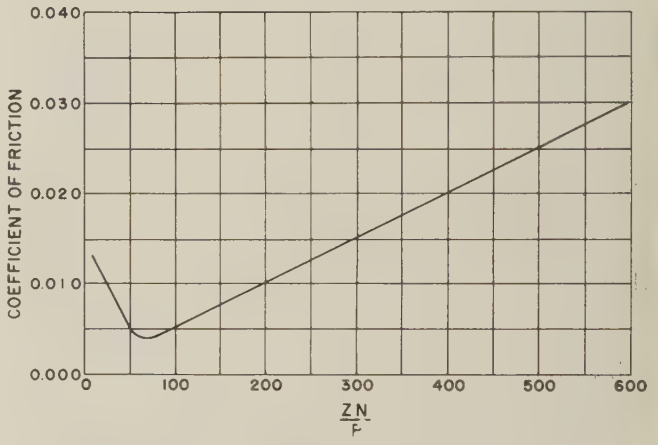

Fig. 1. Typical friction curve of a plain bearing

Figure 2 shows the effect of temperature on the viscosity of oil as given in Sebolt seconds. Knowing this viscosity at 100 to 210°F., one can draw in and extend the curve under consideration. Normal drier bearing

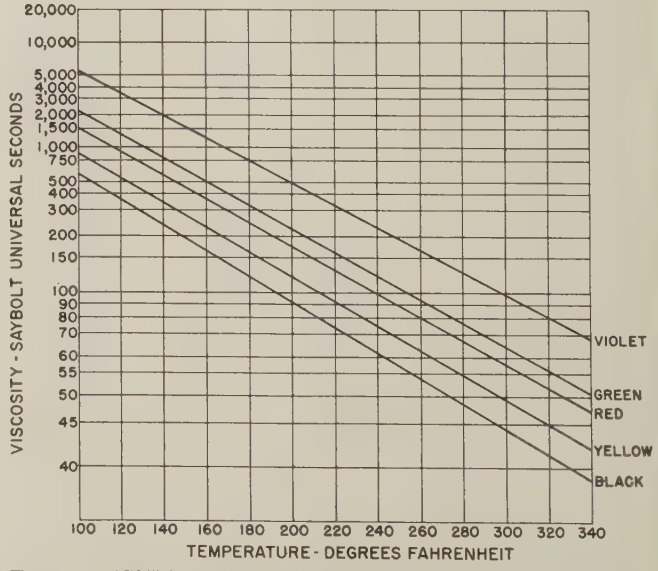

Fig. 2. ASTM standard viscosity-temperature for liquid petroleum products

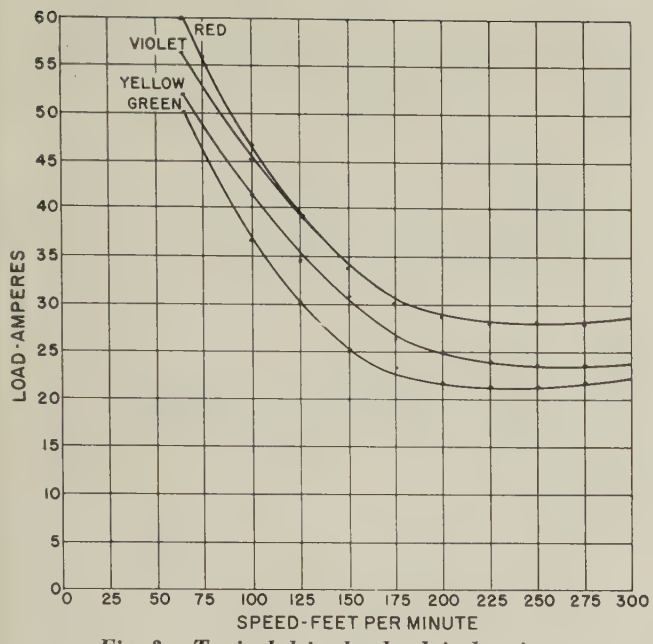

Fig. 3. Typical drier loads plain bearings

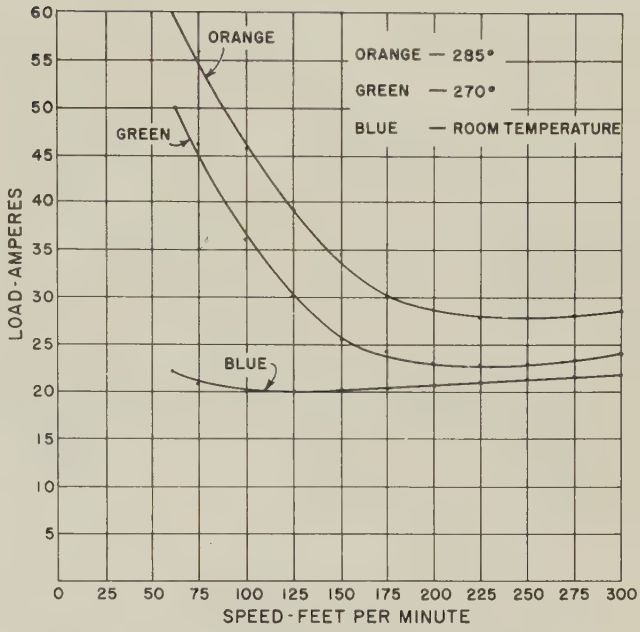

Fig. 5. Effect of temperature on drier loads

oil with a viscosity of 750 at 100° may drop to 45 to 50 under operation conditions. Even using an oil with a viscosity of 2500 at 100°, it will only be 100 at 280. Thus, the problem with an increasing operating steam pressure is apparent.

Now to consider what actually happens.

Figure 3 shows some typical drier load curves of a late design cast iron-journal bronze bushed machine. The design as compared to other machines is good. The tests were made using a recognized variable voltage drive. The load is given in amperes which indicate torque or coefficient of friction. The speed is given in feet per minute. The viscosity and unit pressure can be considered a constant.

Here the pattern begins to unfold.

Figure 4 covers a wider range of study beginning with the actual break away and extending the speeds to 400 f.p.m. These tests are of a different but similar machine than those shown on Fig. 3, but the same pattern is present. Here various oils were tried in an effort to obtain proper operating conditions. The blue curve has a viscosity of 500 to 100° while the red curve has a viscosity of 1892 to 100°, the other two falling in between. Here there is little hope for a proper solution. This machine should and does run over 150 f.p.m.

Figure 5 gives a comparison of the loads or coefficient of friction as effected by operating temperatures.

The blue curve was taken at room temperature, the green test at 270°, and the orange one at 285°. This would compare to running a drier section at 0, 38, and 50 p.s.i.

Figure 6 gives a similar comparison, but over a wider range of speeds. Here tests were made at 80 and 270°.

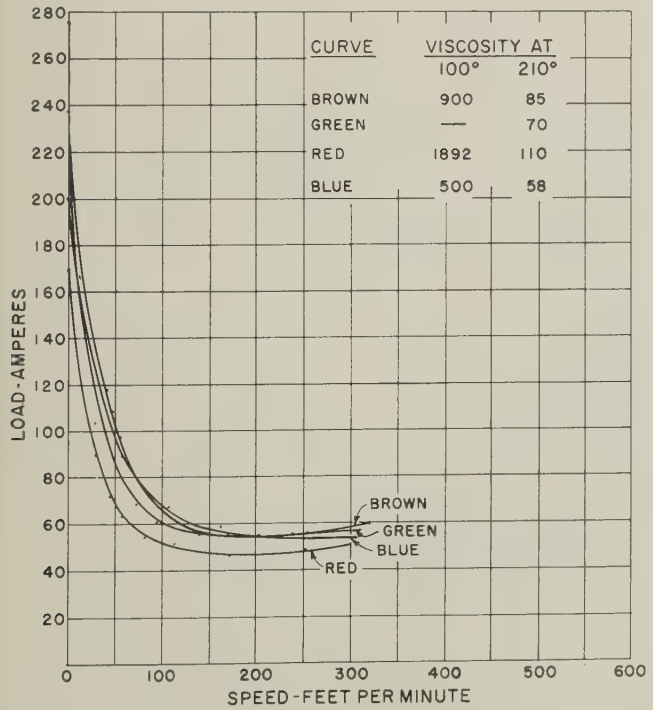

Fig. 4. Effect of oil on drier loads

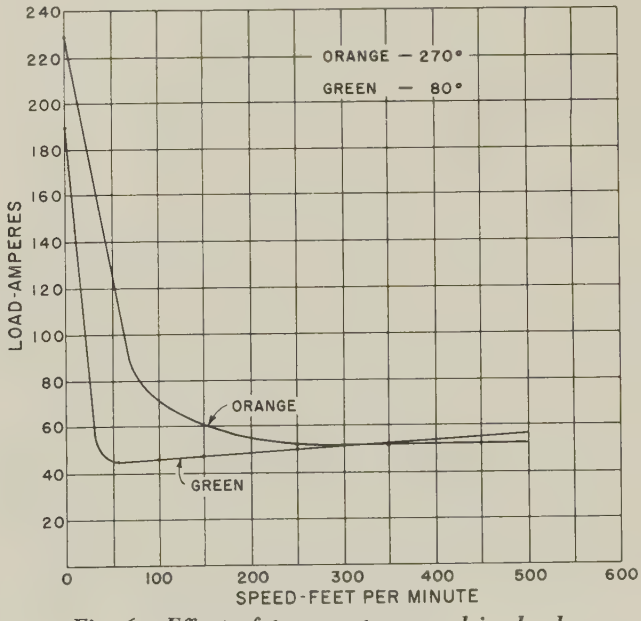

Fig. 6. Effect of temperature on drier loads

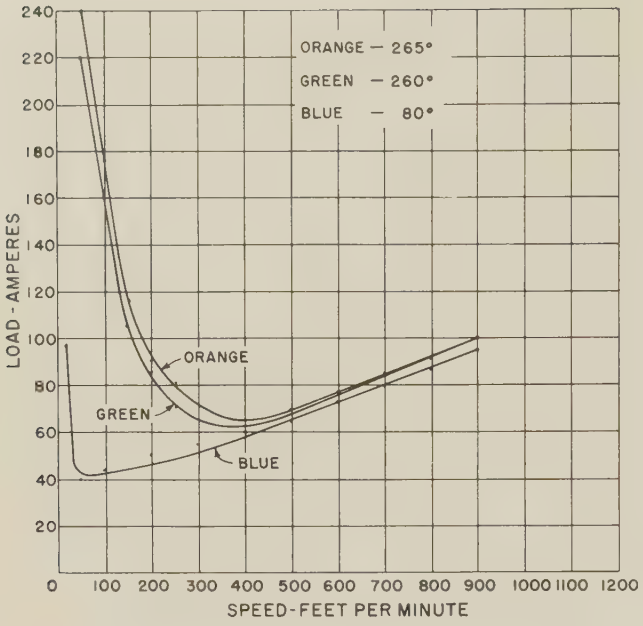

Fig. 7. Effect of temperature on drier loads

The green curve definitely takes the shape of that shown in Fig. 1, which is the basis for the design of plain bearings. The problem with the drier bearings is somewhat more difficult in that the temperature of the journal for the most part is from within and not from friction. The shift in the curve is shown by the comparison of the blue and orange curves. For all practical purposes the temperature of the thin film of oil doing the actual lubricating of the bearing is the same as the journal regardless of the circulating oil temperature. In addition to the problem of bearing maintenance, one can understand why the drive situation is now more acute than in days of low pressure.

Figure 7 gives some indication of what happens on high-speed machines. It also confirms the effect of temperatures. The blue curve was taken at 80° or room temperature, and is almost identical to that shown in Fig. 1. Here the minimum or critical operating speed is at about 150 f.p.m. The green curve was taken at 260° and the orange curve was taken at 265°. With higher pressures and resulting higher temperatures, one can visualize where the curve will go.

Figure 8 gives a comparison of drier loads and temperature during operation. The orange curve is load in amperes; the green one is temperature; the speed was 450 f.p.m. and constant. The steam was shut off at 9:30 and on again at 1:00; as the temperature went down, then, up, so went the load.

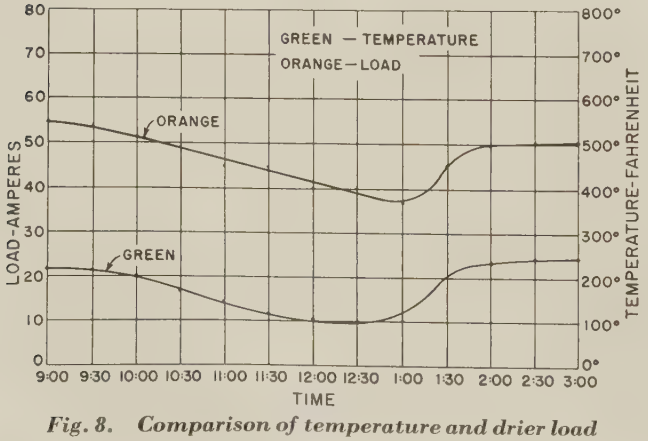

Fig. 8. Comparison of temperature and drier load

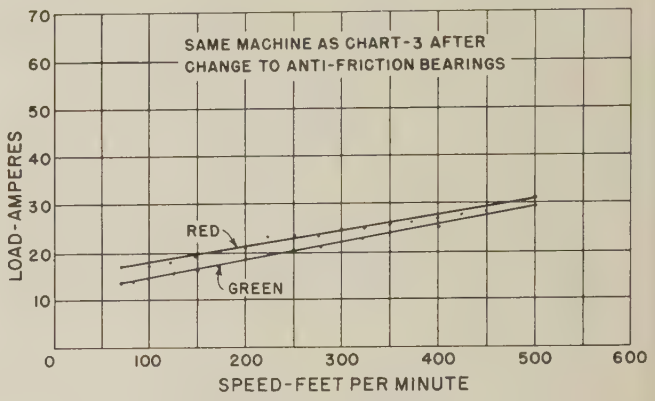

Fig. 9. Typical drier load antifriction bearings

Figure 9 shows the results of two tests on a machine equipped with antifriction bearings, this machine being the same one as tested in Fig. 3.

In conclusion let's look at a comparison of these curves as made from tests of plain and antifriction bearings.

The red curve of Fig. 10 shows the load in amperes of a drier section equipped with plain bearings. The yellow curve was taken a little over a year later, after antifriction bearings had been installed on the front side. Some of this reduction in load resulted from wearing in of the drier section over that period, the balance was due to the reduction in friction of the front side bearings. Both of these tests were taken with the section belted in for a maximum speed of approximately 300 f.p.m.

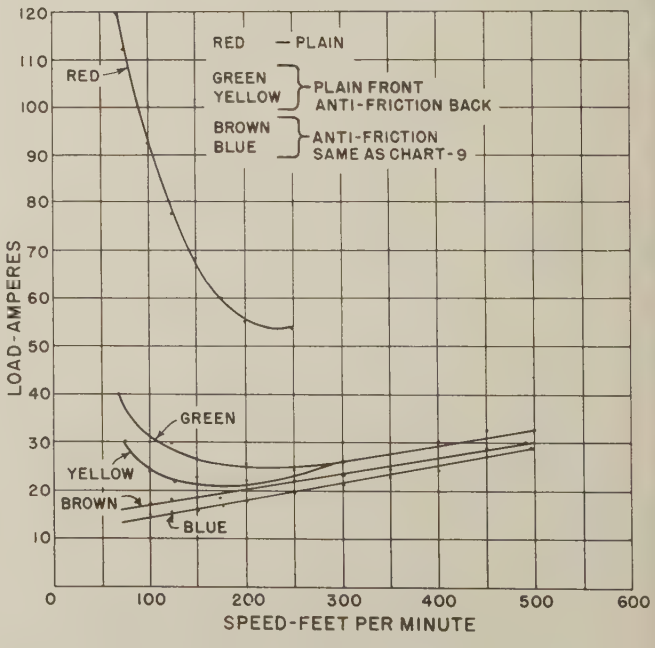

Fig. 10. Comparison of plain and antifriction bearings drier loads

The green curve gives a comparison of the readings taken on the driving unit when connected to give a maximum speed of approximately 500 f.p.m. Here can be seen that from the practical limitations of this paper that the difference in losses of the driving equipment has little effect in comparison to the other variables. The brown and blue curves were taken after the antifriction bearings were installed on the backside of the drier section, and it will be noted that under 250 f.p.m. they do not have the rise in load with decreasing speeds, as has been common on all of the plain bearing installations.

As mentioned before, the information given should not be directly applied to all conditions, and it should be considered only as a basis in analyzing any particular plain bearing installation.

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Chemical Composition of Common North American Pulpwood Barks*

YING-PE CHANG and RAYMOND L. MITCHELL

Components determined in 9 softwood and 15 hardwood barks were as follows: ash, extractives, "lignin," methoxyl in "lignin" and bark, and the amount and composition of the reducing sugars produced from extractive-free bark by 72% H_2SO_4. The hot-water extract was tested qualitatively for tannins by two methods. Solubility of bark in 1% NaOH and the amount of precipitate obtained by acidifying the alkaline extract were also determined. Heat of combustion values were measured for 8 softwood and 12 hardwood barks. Most of the barks contain relatively large amounts of ash, extractives, "lignin," and material soluble in 1% NaOH. The high solubility in alkali, exceeding 50% for seven barks, suggests a potential means for utilizing these barks. Apparent trends in the relation of chemical composition to physical structure of bark are discussed briefly.

The literature on the chemical composition and methods for the proximate analysis of barks has been adequately covered in reviews by Hay and Lewis (*13*), Schwartz (*32*), Segall and Purves (*33*), and Kurth (*16, 17*). References that pertain to the barks analyzed in this study are listed in Table I.

The present study was suggested by the Fundamental Research Committee of the Technical Association of the Pulp and Paper Industry and has been supported by TAPPI Research Grant No. 62. Its purpose was to obtain comparative information on the chemical composition of a number of pulpwood barks. The barks from 24 common pulpwood species were selected, 20 of which were used in a study on the anatomy of barks that was published as TAPPI Monograph No. 14 (*6*). Information obtained from the comparative analysis of this large group of barks should serve as a basis for further research in the chemistry of these barks and possibly lead to their better utilization.

MATERIALS

Bark specimens used were mainly those collected for the previous anatomical studies (*6*), but some new specimens were added. Sample blocks about 1 ft. in length with both wood and bark were cut at breast height from average-growth trees. They were kept at 36°C. and 85% R.H. until prepared for analysis. Species names of barks and the locality of their collection are shown in Table I.

A composite sample of the whole bark from three different trees was prepared for each species except sugar maple, of which there were only two trees represented. Barks were peeled off from the cambial zone by hand to ensure that no wood was attached. Before the bark chips were ground, small knots and any foreign material, such as lichens, mosses, or soil, were removed. The bark was ground in a Wiley mill just long enough to permit passage of the entire sample through a 20-mesh screen. The well-mixed composite samples were air-dried and kept in a balance room maintained at 35% R.H. Bark residues from the various extractions were kept in the same manner.

METHODS OF ANALYSIS

The methods used to analyze barks in this study were for the most part developed for the analysis of wood. TAPPI procedures used in the analysis of wood to determine ash, methoxyl, lignin, and the solubility in alcohol-benzene and in 1% NaOH were applied to bark.

The TAPPI procedure for solubility in hot water was modified because of possible temperature effects on the extraction of tannin from barks. Successive extractions of 2 hr. each at 90°C. were made with two 100-ml. portions of water. The weight of material dissolved was determined after evaporating the combined water extract and washings.

Hot-water extracts were tested qualitatively for tannin by gelatin solution (*36*).

The precipitate formed by refluxing the hot-water extracts with formaldehyde and hydrochloric acid (*3*) was also determined. The procedure for this test is briefly as follows: Extract a 2-gram sample of bark with 100 ml. of water in a boiling-water bath for 1 hr. and decant through a filter; repeat the extraction with an additional 100 ml. of water, filter, and wash. After they have cooled, make up the filtrate and washings to a 500-ml. volume; pipet 100 ml. of the solution into a

Ying-Pe Chang, collaborator, and Raymond L. Mitchell, chemist, Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, maintained at Madison, Wis., in cooperation with the University of Wisconsin.

* This report was prepared under the sponsorship of the Fundamental Research Committee through TAPPI Research Grant No. 62.

Table I. Bark Samples, Their Source, and References to Previous Work

Species	Locality of collection	Literature reference
Softwoods		
1. *Abies balsamea* (L.) Mill. (balsam fir)	Oneida Co., Wis.	(*7, 13, 24*)
2. *Larix occidentalis* Nutt. (western larch)	Northern Rocky Mountain Forest and Range Experiment Station, Mont.	....
3. *Picea engelmannii* Parry (Engelmann spruce)	Priest River, Idaho	....
4. *Picea mariana* (Mill.) B.S.P. (black spruce)	Oneida Co., Wis.	(*1, 2, 7, 24*)
5. *Pinus banksiana* Lamb. (jack pine)	Adams Co., Wis.	....
6. *Pinus contorta* Dougl. (lodgepole pine)	Carson, Wash.	....
7. *Pinus elliottii* Engelm. (slash pine)	Dooly Co., Ga.	....
8. *Pinus lambertiana* Dougl. (sugar pine)	Roseburg, Ore. Placerville, Calif.	(*19*)
9. *Tsuga canadensis* (L.) Carr. (eastern hemlock)	Oneida Co., Wis.	(*7*)
Hardwoods		
10. *Acer negundo* (L.) (boxelder)	So. Miss. Sent by U. S. Forest Service, Miss. Delta Research Center	....
11. *Acer saccharum* Marsh. (sugar maple)	Hardin Co., Ill.	....
12. *Alnus rubra* Bong. (red alder)	Benton Co., Ore.	(*18*)
13. *Betula alleghaniensis* Britton (yellow birch)	Oneida Co., Wis.	(*24*)
14. *Betula papyrifera* Marsh. (paper birch)	Oneida Co., Wis.	(*24*)
15. *Carya illinoensis* (Wangenh.) K. Koch (sweet pecan)	So. Miss. Sent by Miss. Delta Research Center, U. S. Forest Service	....
16. *Liquidambar styraciflua* L. (sweetgum)	Hardin Co., Ill.	....
17. *Nyssa sylvatica* Marsh. (blackgum)	Hardin Co., Ill.	....
18. *Platanus occidentalis* L. (American sycamore)	Hardin Co., Ill.	....
19. *Populus heterophylla* L. (swamp cottonwood)	So. Miss. Sent by Miss. Delta Research Center, U. S. Forest Service	....
20. *Populus tremuloides* Michx. (quaking aspen)	Oneida Co., Wis.	(*5, 25*)
21. *Quercus alba* L. (white oak)	Hardin Co., Ill. Sauk City, Wis.	(*15*)
22. *Quercus rubra* L. (northern red oak)	Hardin Co., Ill. Sauk City, Wis.	....
23. *Salix nigra* Marsh. (black willow)	Hardin Co., Ill.	....
24. *Ulmus americana* L. (American elm)	Hardin Co., Ill. So. Miss. Sent by Miss. Delta Research Center, U. S. Forest Service	....

250-ml. Erlenmeyer flask, add 10 ml. of 40% HCHO and 5 ml. of conc. HCl; reflux for 30 min.; filter through a medium porosity, fritted glass crucible; wash the precipitate with 200 ml. of distilled water; dry the precipitate for 2 hr. at 105°C. and weigh.

Reducing sugar produced by hydrolysis of barks with 72% H_2SO_4 was determined as glucose (*30*). Individual sugars in the hydrolyzates from bark were separated and determined by the techniques of paper chromatography developed for the analysis of pulp (*31*).

The heat of combustion values were determined by the standard method (*8*).

All determinations were made in duplicate, except the extractions and chromatographic analyses of sugars, which were made in quadruplicate.

RESULTS

Ash

The high ash content values found for bark in the present study are similar to published data on other barks (Table II). The ash content of softwood barks ranged from 0.6 to 2.5%; of hardwood barks, from 1.5 to 10.7%.

Extractions

Extractions of barks were made successively with benzene, 95% alcohol, hot water, and 1% NaOH. Bark residues from successive extractions with benzene, alcohol, and hot water were designated extractive-free barks. Results of the extractions are shown in Table II.

Solubility in benzene varied from 0.5% for elm to 28.7% for lodgepole pine. Relatively large amounts of benzene-soluble materials were found for lodgepole pine and balsam fir among the softwood barks, and for paper birch among the hardwood barks.

Material extracted by 95% alcohol ranged from 3.3 to 25.9% and exceeded 10% for eight softwood barks and six hardwood barks. Less material was removed by the hot-water extraction—2.4 to 10.9%.

The amount of material removed by a 1% NaOH extraction was between 20 and 30%, except for jack pine (41.3%) and sugar pine (36.0%). The alkali-soluble material represents 50% or more of the total material dissolved in the series of successive extractions

Table II. Ash Content and Various Extractions of Bark
(Percentages on basis oven-dry weight of unextracted bark)

Species	Ash, %	Material dissolved by successive extractions with: Benzene, %	95% alcohol, %	Hot water, %	1% sodium hydroxide, %
1. Balsam fir	2.3	13.2	3.3	2.7	30.6
2. Western larch	1.6	1.3	14.8	3.8	22.7
3. Engelmann spruce	2.5	5.2	25.9	10.9	22.2
4. Black spruce	2.0	5.0	14.6	4.4	28.0
5. Jack pine	1.7	8.0	12.4	3.0	41.3
6. Lodgepole pine	2.0	28.7	10.9	5.6	29.8
7. Slash pine	0.6	3.4	10.6	3.7	28.9
8. Sugar pine	0.6	1.5	21.7	3.2	36.0
9. Eastern hemlock	1.6	2.8	21.2	3.3	24.6
10. Boxelder	6.2	2.4	6.3	6.2	23.7
11. Sugar maple	6.3	1.2	3.9	2.4	19.2
12. Red alder	3.1	2.3	3.9	3.7	27.5
13. Yellow birch	1.7	4.3	10.8	2.3	28.4
14. Paper birch	1.5	9.4	10.5	2.5	25.1
15. Sweet pecan	7.5	0.8	18.4	5.4	25.3
16. Sweetgum	5.7	1.5	17.7	7.4	21.3
17. Blackgum	7.2	2.5	4.6	5.3	27.8
18. Sycamore	5.8	2.1	6.0	3.6	22.0
19. Swamp cottonwood	4.0	1.9	8.0	4.8	20.2
20. Quaking aspen	2.8	4.0	11.6	4.7	22.0
21. White oak	10.7	2.7	4.4	5.8	26.5
22. Northern red oak	5.4	4.8	7.9	3.6	22.3
23. Black willow	6.0	1.6	3.8	4.8	23.8
24. American elm	9.5	0.5	10.1	6.0	27.0

for 20 of the barks. A lower proportion of alkali solubility was found for Engelmann spruce, lodgepole pine, eastern hemlock, and sweetgum.

The unextracted or original barks were extracted with 1% NaOH. The amount of soluble material and yield of precipitate obtained by acidification of the alkaline extract are shown in Table III.

The 1% NaOH extraction of the original bark removed approximately the same amount of material as did the preceding series of successive extractions using benzene, 95% alcohol, hot water, and 1% NaOH.

A precipitate was obtained by adding 5 ml. of concd. HCl to 50 ml. of the original extract, undiluted with wash water. The precipitate was extremely difficult to filter through a fritted glass crucible even after standing at room temperature for 24 hr. Heating the acidified filtrate for 30 min. at 95°C. produced an easily filterable precipitate. The amount of precipitate obtained varied from 18 to 34% of softwood barks and 6 to 15% of hardwood barks, on the basis of the original bark.

The addition of 10 ml. of 40% HCHO to the acidified filtrate followed by heating for 30 min. at 95°C. produced an increase in the yield of precipitate for the eight barks tested. This suggests the presence of phenolic compounds capable of condensing with formaldehyde.

The hot water extracts of barks were tested qualitatively for tannin by the gelatin method. The precipitates formed by reaction with formaldehyde-hydrochloric acid were also determined. Results of these tests and the percentages of tannin reported in the literature are shown in Table IV.

Table III. Precipitation of Material from the 1% NaOH Extract of Bark

(Percentages based on oven-dry weight of original bark)

Species	*Material soluble in 1 % NaOH*	*Precipitate formed by acidification of alkaline extract[a]* — *Room temperature, %*	*95°C.— 0.5 hr., %*	*Formaldehyde,[b] 95°C.— 0.5 hr., %*
1. Balsam fir	49.4	17.6	24.0	..
2. Western larch	43.6	10.9	17.9	19.2
3. Engelmann spruce	64.0	..	23.1	24.4
4. Black spruce	51.6	11.6	19.8	20.4
5. Jack pine	62.6	..	25.4	..
6. Lodgepole pine	72.9	..	29.9	..
7. Slash pine	48.5	..	19.8	21.1
8. Sugar pine	62.7	..	33.7	42.8
9. Eastern hemlock	51.7	..	22.7	23.6
10. Boxelder	39.7	..	6.0	..
11. Sugar maple	28.3	..	7.2	..
12. Red alder	37.8	..	13.2	..
13. Yellow birch	46.9	..	14.6	..
14. Paper birch	42.9	..	13.2	16.3
15. Sweet pecan	50.9	..	6.7	..
16. Sweetgum	48.3	..	9.0	11.5
17. Blackgum	39.4	..	10.4	..
18. Sycamore	33.4	..	4.6	..
19. Swamp cottonwood	35.0	..	6.3	..
20. Quaking aspen	41.8	..	11.6	..
21. White oak	38.2	..	7.5	..
22. Northern red oak	39.8	..	12.9	..
23. Black willow	35.3	..	7.9	..
24. American elm	45.2	..	11.5	..

[a] Five milliliters of concentrated hydrochloric acid/50 ml. of undiluted extract.
[b] Ten milliliters of 40% CHOH added to the acidified filtrate.

The gelatin test indicates that the barks in this group contain at least traces of tannin. The amount of gelatin precipitate obtained with hot-water extracts from the barks was compared with the precipitate in standards of known concentration prepared from "Myrtan," a commercial tannin extract. This provided a rough approximation of the relative amounts of tannin in the barks.

Table IV. Results of the Gelatin Test for Tannins and the Reaction of Hydrochloric Acid-Formaldehyde with Hot-Water Extracts of Barks

(Percentage tannin-formaldehyde precipitate on basis of oven-dry unextracted bark)

Species	*Relative amounts of gelatin precipitate (visual comparison)*	*Tannin-formaldehyde precipitate, %*	*Tannin content reported in literature, %*
1. Sugar pine	Large	15.3	4.9–7.1 (*20*)
2. Eastern hemlock	Large	15.0	6.8–12.2 (*26*), 11.3 (*29*), 12–14 (*34*)
3. Sweetgum	Large	10.2	Insignificant (*29*)
4. Western larch	Large	12.7	.....
5. Engelmann spruce	Large	23.2	.....
6. Slash pine	Medium	8.7	.....
7. Sweet pecan	Medium	9.5	5.7 (*29*)
8. Black willow	Medium	4.0	5.1 (*29*)
9. American elm	Medium	5.6	2.8 (*29*)
10. Jack pine	Small	8.3	.....
11. Blackgum	Small	1.7	Insignificant (*29*)
12. White oak	Small	2.8	2.3–5.1 (*23*), 6.3 (*15*), 6.1–6.6 (*4*), 7.9 (*29*)
1. Northern red oak	Small	2.2	5.4–6.4 (*26*), 10.9 (*29*)
2. Black spruce	Small	10.8	6.6 (*23*), 8.3–12.2 (*9*)
3. Yellow birch	Trace	5.5	1.5–3.1 (*26*), 4.4 (*29*)
4. Paper birch	Trace	6.2	1.6–3.3 (*26*)
5. Sugar maple	Trace	2.9	1.9 (*26*)
6. Quaking aspen	Trace	3.3	5.0 (*26*)
7. Swamp cottonwood	Trace	2.7	.....
8. Lodgepole pine	Trace	4.9	.....
9. Red alder	Trace	2.1	4.2 (*18*)
10. Sycamore	Trace	2.9	1.9 (*29*)
11. Boxelder	Trace	1.4	Insignificant (*29*)
12. Balsam fir	Trace	2.2	3.1 (*13*), 3.4–4.1 (*26*)

The hot-water extracts from barks were treated with formaldehyde-hydrochloric acid to precipitate the catechol tannins. The reaction is not specific for catechol tannins, however, since other phenolic compounds react with formaldehyde to produce an insoluble precipitate. Action of the acid alone may cause condensation of tanninlike materials or hydrolyze glycosidic materials to yield water-insoluble products.

The yields of tannin-formaldehyde precipitate obtained for sugar pine, sweetgum, pecan, elm, and paper birch are greater than the tannin content reported for these barks. Conversely, balsam fir and red oak barks yielded smaller amounts of precipitate than their reported tannin content.

Reducing Sugars

A measure of the carbohydrate material in bark was obtained by determining the reducing sugar produced by hydrolysis of the bark with 72% H_2SO_4. The yields of reducing sugar, measured as glucose, for original bark, extractive-free bark, and extractive-free bark

that had been extracted with 1% NaOH are given in Table V.

The amount of reducing sugar obtained from hydrolysis of barks is much less than that obtained for most woods (*30*).

Table V. Reducing Sugars Produced by Hydrolysis of Bark with 72% H_2SO_4

(Percentage, as glucose, based on oven-dry, unextracted bark)

Species	Reducing sugars from: Unextracted bark, %	Extractive-free bark, %	Alkali extracted bark,[a] %
1. Balsam fir	46.6	45.3	32.9
2. Western larch	46.6	46.0	38.0
3. Engelmann spruce	42.9	34.3	24.2
4. Black spruce	47.9	44.8	32.3
5. Jack pine	30.6	28.8	21.1
6. Lodgepole pine	38.3	32.9	19.2
7. Slash pine	29.7	29.8	26.4
8. Sugar pine	22.1	19.8	16.1
9. Eastern hemlock	34.9	33.3	29.1
10. Boxelder	40.6	37.8	30.0
11. Sugar maple	35.4	34.3	31.1
12. Red alder	38.6	38.0	30.3
13. Yellow birch	32.5	31.8	26.0
14. Paper birch	32.2	30.1	21.8
15. Sweet pecan	33.5	30.7	23.3
16. Sweetgum	35.6	33.5	26.4
17. Blackgum	29.6	27.2	22.4
18. Sycamore	40.9	39.0	31.1
19. Swamp cottonwood	41.0	39.2	34.1
20. Quaking aspen	41.4	39.7	34.9
21. White oak	27.8	28.2	21.2
22. Northern red oak	32.4	31.7	28.3
23. Black willow	42.9	43.4	35.4
24. American elm	37.0	35.4	27.0

[a] Extractive-free bark extracted with 1% NaOH.

Hydrolyzates from extractive-free barks were used in the separation and determination of reducing sugars by means of paper chromatography. The sugar solutions were applied to Whatman no. 1 paper and irrigated for approximately 100 hr. with butanol-pyridine-water solvent (10:3:3 by volume). Separation of the sugars was adequate for present purpose but not as good as that for the three sugars from the hydrolysis of purified pulps. The sugars were determined as glucose, corrected for decomposition during hydrolysis, and for relative reducing power with respect to glucose. Each sugar was reported as a percentage of the total reducing sugar. There was in addition to the five sugars, a band of reducing material, perhaps acidic carbohydrates, located at R-glucose, 0.12 to 0.19. This unknown material was reported in terms of glucose as a percentage of the total reducing sugar. The composition of the reducing sugars from the 24 barks is shown in Table VI.

The unknown reducing materials (R-glucose, 0.12 to 0.19) were not identified. Qualitative tests showed their behavior on paper chromatograms with ethyl acetate-acetic acid-water solvent was similar to that reported for uronic acid compounds found in the hydrolyzates from sphagnum moss (*35*) and from wood (*14, 27*). None of these reducing materials were detected in the hydrolyzates from six barks that had been extracted with 1% NaOH.

Glucose is the major component of the reducing sugars—50 to 70%. Galactose and mannose are greater in softwood than in hardwood barks, as is the case for the two classes of woods. The proportions of arabinose and xylose in barks differs somewhat from the patterns observed in woods (*10*). Arabinose exceeds xylose in lodgepole pine and is approximately equal to xylose in the other softwood barks, except slash pine. Hardwood barks, unlike their woods, contain appreciable amounts of arabinose.

The sugars from hydrolysis of six extractive-free barks that had been extracted with 1% NaOH were also analyzed by paper chromatography (Table VII). Proportions of the different reducing sugars were not substantially affected by the alkaline extraction. No reducing material was detected at R-glucose 0.12 to 0.19 on the paper chromatograms of these hydrolyzates.

"Lignin"

The term lignin is usually reserved for the insoluble product obtained from extractive-free wood by the 72% H_2SO_4 or by other means. Extractive-free bark yields an acid-insoluble product by the 72% H_2SO_4 method; this product from bark will be referred to as "lignin," although the name is not satisfactory for several reasons. It is possible that a fraction of true lignin occurs in bark "lignin," but available information indicates that a fundamental difference exists between the structure and composition of wood lignin and bark "lignin" (*11, 21, 22*).

"Lignin" was determined in extractive-free bark and in alkali-extracted bark, the residue remaining from a 1% hydroxide extraction of extractive-free bark. Ash was not determined in the "lignin" residues.

Table VI. Composition of Reducing Sugars from Hydrolysis of Extractive-Free Barks with 72% of H_2SO_4

(Percentages based on total reducing sugar)

Species	Glucose, %	Unknown substances (R glucose 0.12–0.19), %	Galactose, %	Mannose, %	Arabinose, %	Xylose, %
1. Balsam fir	64	3	5	12	9	7
2. Western larch	69	1	4	11	6	9
3. Engelmann spruce	61	3	5	9	13	9
4. Black spruce	64	3	6	7	11	9
5. Jack pine	64	2	7	6	10	11
6. Lodgepole pine	50	3	7	6	26	8
7. Slash pine	63	1	7	7	7	15
8. Sugar pine	69	1	6	8	7	9
9. Eastern hemlock	67	2	3	13	8	7
10. Boxelder	65	3	3	2	7	20
11. Sugar maple	63	2	3	1	6	25
12. Red alder	54	2	3	1	6	34
13. Yellow birch	54	2	3	1	8	32
14. Paper birch	53	2	2	1	6	36
15. Sweet pecan	69	4	4	1	11	11
16. Sweetgum	60	3	3	3	11	20
17. Blackgum	60	3	4	1	8	24
18. Sycamore	59	2	4	1	4	30
19. Swamp cottonwood	61	3	4	1	5	26
20. Quaking aspen	60	2	2	1	5	30
21. White oak	60	3	4	2	7	24
22. Northern red oak	53	2	3	1	6	35
23. Black willow	69	3	3	1	6	18
24. American elm	70	4	4	2	9	11

Methoxyl was determined in the "lignin" residues and the original bark. Results from these determinations are shown in Table VIII.

The amount of "lignin" varies from 14.8% for lodgepole pine to 49.9% for slash pine and sugar pine, among

the softwood barks. The "lignin" in hardwood barks varies from about 25% for pecan and sweetgum to 40% for yellow birch and red alder. Alkali extraction removes a large part of "lignin" from bark, especially with the pines and spruces. Loss of "lignin" from hardwood barks by the alkaline extraction ranged from 20 to 45% of the "lignin" in the extractive-free bark.

The methoxyl in "lignin" from softwood barks was low—3.9 to 8.9%. "Lignin" from hardwood barks varied from 7.3 to 15.0%. The methoxyl content of "lignin" from alkali-extracted bark was in every instance greater than that of "lignin" from extractive-free bark. Thus the alkali extraction dissolved a "lignin" fraction containing less methoxyl than the alkali-insoluble "lignin" fraction.

The methoxyl content of the unextracted or original barks is relatively low. The proportion of methoxyl in the "lignin" fraction of barks is quite variable, ranging from about 37% for lodgepole pine to 89% for yellow birch.

Table VII. Composition of Reducing Sugars from Hydrolysis of Alkali-Insoluble Bark Residues[a] by 72% H_2SO_4
(Percentages based on total reducing sugar)

Species	Glucose, %	Galactose, %	Mannose, %	Arabinose, %	Xylose, %
Western larch	74	4	9	4	9
Slash pine	67	6	7	5	15
Eastern hemlock	76	2	10	5	7
Sugar maple	69	2	1	4	24
Paper birch	55	2	1	5	37
Sweetgum	71	2	1	5	21

[a] Residues from the 1% NaOH extraction of extractive-free bark.

Table VIII. "Lignin"[a] and Methoxyl of "Lignin" and of Bark

Species	"Lignin" from extractive-free bark		"Lignin" from alkali-extracted bark		Methoxyl in unextracted bark, %
	Yield[b], %	Methoxyl,[c] %	Yield,[b] %	Methoxyl,[c] %	
1. Balsam fir	27.7	8.5	15.0	12.7	3.30
2. Western larch	30.0	8.9	19.6	10.7	3.14
3. Engelmann spruce	17.9	7.2	8.7	9.7	2.90
4. Black spruce	25.3	8.2	14.4	10.0	3.20
5. Jack pine	42.2	4.7	14.4	10.1	3.07
6. Lodgepole pine	14.8	5.1	5.4	8.1	1.99
7. Slash pine	49.9	6.3	26.1	10.2	3.95
8. Sugar pine	49.9	3.9	20.1	8.2	2.45
9. Eastern hemlock	35.8	8.0	20.1	10.5	3.61
10. Boxholder	30.1	11.1	22.8	12.4	4.03
11. Sugar maple	37.3	11.2	27.4	11.9	5.05
12. Red alder	40.9	7.9	28.5	9.2	3.85
13. Yellow birch	40.6	7.6	26.3	9.2	3.46
14. Paper birch	37.8	8.4	22.7	12.1	4.04
15. Sweet pecan	24.9	7.5	16.0	9.5	2.69
16. Sweetgum	25.3	10.7	18.7	12.9	3.37
17. Blackgum	38.3	10.3	25.0	12.5	4.97
18. Sycamore	26.6	15.0	21.3	16.8	5.53
19. Swamp cottonwood	33.4	12.0	27.2	13.7	5.36
20. Quaking aspen	31.2	10.3	21.0	13.6	4.75
21. White oak	31.8	7.3	20.9	9.3	3.28
22. Northern red oak	34.8	9.1	23.3	11.3	4.32
23. Black willow	29.0	9.2	20.9	12.0	3.74
24. American elm	27.5	6.9	16.9	9.7	2.91

[a] The acid-insoluble residue from bark by the 72% H_2SO_4 method; ash not determined in "lignin" residue.
[b] Yield based on oven-dry, unextracted bark.
[c] Yield based on oven-dry weight of the corresponding "lignin" residue.

Heat of Combustion

The heat of combustion of 20 barks was determined on 1-gram samples of air-dry bark. The average values reported in Table IX do not vary more than ±100 cal. from the individual values. The calories per gram values are for barks of the moisture content indicated in the table. The standard factor of 1.8 was used for conversion to B.t.u. per pound.

The heating values of barks are about the same as those reported for woods (*12*). Average heating values of the softwood barks are higher than those of the hardwood barks. Most of the hardwood values are lower than 8000 B.t.u., except those for the two birches and aspen. Heat of combustion values for the barks tested appeared to be affected principally by the amount of ash and the benzene-soluble extractives. A high percentage of ash, as in white oak, tends to give lower heat of combustion values. Appreciable amounts of benzene-soluble material, as for example in lodgepole pine bark, appear to be responsible for higher values. Other types of extractives and the "lignin," because of their relatively high carbon content, also contribute to higher heating values, but the effect is not so obvious.

Table IX. Heat of Combustion of Barks

Species	Moisture content, %	Calories/gram[a]	B.t.u./lb.[a]
1. Balsam fir	6.5	4923	8861
2. Western larch	6.7	4558	8204
3. Engelmann spruce	5.5	4644	8359
4. Black spruce	6.5	4581	8246
5. Jack pine	6.6	4867	8761
6. Lodgepole pine	5.6	5661	10190
7. Slash pine	6.4	5001	9002
8. Sugar pine	..	..	..
9. Eastern hemlock	6.2	4890	8802
10. Boxelder	..	..	..
11. Sugar maple	6.0	4056	7301
12. Red alder	5.8	4415	7947
13. Yellow birch	5.2	5042	9076
14. Paper birch	4.8	5241	9434
15. Sweet pecan	..	..	..
16. Sweetgum	6.2	4139	7450
17. Blackgum	6.0	4409	7936
18. American sycamore	6.4	4113	7403
19. Swamp cottonwood	..	..	..
20. Quaking aspen	5.5	4685	8433
21. White oak	6.5	3886	6995
22. Red oak	4.4	4461	8030
23. Black willow	6.7	3982	7168
24. American elm	6.7	3845	6921

[a] Values are for samples of the indicated moisture content.

The decrease in heating value with increased moisture content of wood and bark has been evaluated (*12*). The high moisture content of barks at the pulp mill as an obstacle to the utilization of barks as a fuel has been discussed in a paper by Rue and Gleason (*28*) in which they record the heating value of several barks.

DISCUSSION

In comparison with woods, barks contain relatively large amounts of ash, extractives, and "lignin" and relatively smaller amounts of carbohydrates.

Definite relationships between chemical composition and anatomical structure of a given bark cannot be

established from data obtained in this study, but some general trends were observed.

The amount of periderm or cork is apparently related to the amount of material soluble in benzene and alcohol, but certain kinds of cork may be fundamentally different in nature from others. Paper birch and American elm barks, for example, each contain a high proportion of cork, but the latter yields only a trace of benzene-soluble extractives.

The relationship of the essential tissue elements in the secondary phloem to cellulose and "lignin" is not consistent. In the hardwood barks, those that contain a high proportion of phloem fibers are proportionally higher in yield of reducing sugar by total hydrolysis than in "lignin." The ratio of reducing sugar to "lignin" becomes greater after extraction with 1% NaOH.

Although the softwood barks are comparatively simpler in structure, containing sieve cells as their major component, there was no apparent relation to chemical composition in the present data. Any relationship along this line may perhaps be confused by the wide variation in extractives in the different species. The amount of parenchymatous cells and sclereids in a bark is quite variable and they are often in the transformative stage of growth. It is difficult to detect any trends in connection with these cells on the basis of present information.

Composite samples are acceptable in general com parative studies of the chemical composition of bark and for purposes of practical application. Obviously, extensive sampling of bark from a given species according to a systematic procedure would be required for fundamental work designed to show the relation of chemical composition to structure or growth factors. Furthermore, chemical procedures should be developed that will permit the determination of the specific chemical constituents in bark.

Some methods of analysis that were designed primarily for wood analysis are not too satisfactory for barks, as, for example, the method for the "lignin" fraction. Studies on the fundamental structure of the "lignins," characterization of the extractives, and an investigation of the acidic carbohydrate fractions of these barks would be of interest.

The chemical utilization of barks has some potential advantages over that of wood, especially with respect to extractives. Barks often contain relatively large amounts of special constituents, such as tannin, that may be absent from wood or present in small amounts The softwood barks that were investigated contained a high percentage of total extractives. Further work on characterizing the extractives is needed in order to establish possible means of utilizing these barks. The yields of extractives obtainable from commercially collected bark would not necessarily be the same as the yields reported in this study.

The amount of material extracted from the original barks by 1% NaOH was approximately the same as that removed by successive extractions with benzene, 95% alcohol, hot water, and 1% NaOH. Most of the extractives in the original bark appear to have been removed by 1% NaOH. The alkaline treatment dissolves 50% or more of several of the barks and may serve as the basis of a simple process for utilizing certain of these barks.

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ASSOCIATION NEWS AND EVENTS

Local Section Meetings

New England: June 3–4, 1955, Oceanside House, Magnolia Mass., annual meeting.

Delaware Valley: May 26, 1955, Engineers Club, Philadelphia, Pa., Edward J. Albert Award Competition.

Empire State: June 9–11, 1955, Whiteface Inn, Lake Placid, N. Y.

Empire State (Eastern District): May 21, 1955, Glens Falls Country Club, Glens Falls, N. Y., annual meeting.

Maine-New Hampshire: June 22–25, 1955, Eastern Slope Inn, North Conway, N. H., annual meeting, "Paper Machine Operating Problems."

Kalamazoo Valley: June 2, 1955, Gull Lake Country Club, Kalamazoo, Mich., Annual Fun Day.

New England

The New England Section will hold its annual meeting at the Oceanside House, Magnolia, Mass., on June 3–4, 1955. A good technical program is being arranged.

Prior to the meeting on Friday, June 3, there will be open house at the Lowell Technological Institute, 1 Textile Ave., Lowell, Mass., from 10 a.m. to 2 p.m. Modern equipment and facilities for paper manufacture are housed on the second

The Lowell Technological Institute at Lowell, Mass.

floor of the Paper and Leather Building, which was completed in 1952 by the Commonwealth of Massachusetts. The equipment includes handsheet facilities, laboratory and pilot plant fiber processing apparatus, a coating machine, chemical and physical testing laboratories, and controlled humidity rooms.

Professor John Lewis is in charge of the Department of Paper Engineering. The department faculty includes Professor Norwood H. Keeney, Jr., and Horace N. Lee, instructor. About 50 students are enrolled in the paper engineering program and several graduates are now employed by the industry.

Tenth Paper-Plastics Conference

J. C. Pullman of the American Cyanamid Co. and chairman of the TAPPI Plastics Conference has announced that the Tenth Paper-Plastics Conference will be held at the Brooklyn Law School, 375 Pearl St., Brooklyn, N. Y., on Nov. 14–15, 1955.

Preliminary plans for the technical program include half-day sessions to deal with the following subjects: (1) What the Plastic Coating Industry Would Like in Coating Materials; (2) Polyethylene Extrusion Coating; (3) Fibrous Laminates; (4) Resins.

Professor Herman Mark of the Polytechnic Institute of Brooklyn will be in charge of the program and arrangements.

The Hotel St. George, Clark St., Brooklyn, N. Y., is located near the Brooklyn Law School.

Other TAPPI Conferences

The Sixth Coating Conference will be held at the Statler Hotel, Cleveland, Ohio, May 23–25, 1955.

The Fifth Fundamental Research Conference will be held at The Institute of Paper Chemistry, Appleton, Wis., on Sept. 15–17, 1955. The theme of the conference will be "The Theories of Bleaching."

The Second Mechanical Pulping Conference will be held at the Poland Spring House, Poland Spring, Me., on Sept. 19–21, 1955.

The Fifth Testing Conference will be held at the Sheraton-Kimball Hotel, Springfield, Mass., on Sept. 28–30, 1955.

The Fifth Corrugated Containers Conference will be held at the Morrison Hotel, Chicago, Ill., on Oct. 5–7, 1955.

The Ninth Alkaline Pulping Conference will be held at the Hotel Patton, Chattanooga, Tenn., on Oct. 19–21, 1955.

The 41st Annual Meeting of the Technical Association will be held at the Commodore Hotel, New York, N. Y., on Feb. 20–23, 1956.

Canadian Summer Meeting

The Summer Meeting of the Technical Section of the Canadian Pulp & Paper Association will be held at the Chateau Frontenac, Quebec City, P. Q., on June 6–8, 1955.

The meeting will be featured by the presence of about 40 members of the Technical Section of the British Paper and Board Manufacturers Association who will present papers on pulp and paper testing, causes of basis weight variation on the paper machine, dyeing of paper stock; new developments in couching.

Other subjects to be considered include: ventilation, low versus high-speed refining; discussion of vacuum pick-up installations; and the nature of the groundwood process.

TAPPI Research Appropriations

John L. Parsons, chairman of the TAPPI Research Appropriations Committee, has advised that the Technical Association to date spent more than $150,000 to finance research projects of benefit to the pulp, paper, and converted products industries.

Appropriations were awarded to the Acid Pulping, Alkaline Pulping Chemical Engineering, Chemical Methods, Coating, Corrugated Containers, Drying, and Ventilating, Fibrous Materials Testing, Materials of Construction, Microscopy, Mechanical Pulping, Paper Testing, Pulp Testing, Plastics, Water, and Structural Fibrous Materials Committees.

More than $45,000 were granted to the Fundamental

Research Committee and about $20,000 to the Hydraulics Committee.

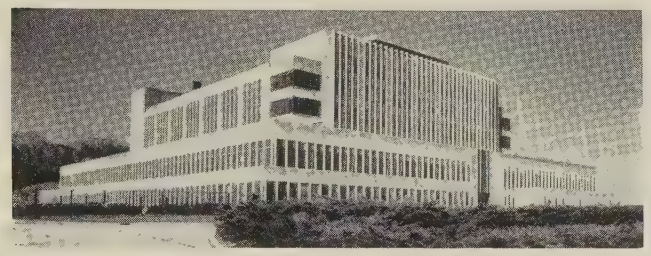
Fourth Statistics Conference

Statistical techniques that have proved effective and profitable in solving paper mill problems will constitute the subject matter of the 1955 TAPPI Conference on Statistics in the Paper Industry. The Conference will be held at the Forest Products Laboratory, Madison, Wis., July 11 to 23, 1955, under the co-sponsorship of the TAPPI Statistics Committee and the Forest Products Laboratory.

The conference will consist of two courses: elementary and advanced seminar, running concurrently. The elementary course will deal with the basic statistical techniques, analysis of variance and simple and multiple regression, used to handle the complex matter of variation in a paper mill. From the mill point of view this involves estimating and comparing precision of tests and testing equipment; analyzing and controlling or improving machine direction and cross machine variation; finding and measuring the effects of other causes of variation in a paper mill; finding and estimating the nature of causal relationships in a paper mill.

The advanced seminar course will deal with advanced applications of statistical methods, particularly multiple regression and correlation and design of experiments. It will be run as a seminar and those enrolling are encouraged to bring their problems for individual consultation and discussion.

Residence will be in Kronshage Hall beside Lake Mendota on the campus of the University of Wisconsin with convenient access to swimming and other facilities for off-time recreation. Classes will be held in the Forest Products Laboratory.



Headquarters for American forest research is this imposing structure at Madison, Wis., the U. S. Forest Products Laboratory where the Statistics Conference will be held

The fee including cost of instruction, textbooks, course material, board, and lodging will be $200 for the elementary course, $260 for the advanced seminar course with an extra charge of $40 per week to cover board and lodging for wives accompanying their husbands to Madison.

Enrollment will be limited to 40 in the elementary course and 10 in the advanced seminar. In order to allow for wider representation the right is reserved to limit enrollment to four people from any one company or organization.

Application for enrollment should be made to: Fred R. Sheldon, Becco Chemical Division, Food Machinery Corp., Station B, Buffalo 7, N. Y.

Tenth Engineering Conference

The Tenth TAPPI Engineering Conference will be held at the Rice Hotel, Houston, Tex., on Nov. 7–9, 1955 (note change from previously announced dates). Following are the tentative programs being sponsored by the committees of the Engineering Division:

Engineering Research and Machine Design

"Use of Computers in Machine Design," by R. C. Berger, General Electric Co., Cleveland, Ohio.

"Paper Stock Agitation," by J. Y. Oldshue, Mixing Equipment Co., Mount Read Blvd., Rochester, N. Y.

"Noise Abatement" (author to be announced).

Steam and Power

"Waste Sulphite Liquor Burning," by Frank Coldwell, Nekoosa Edwards Paper Co., Port Edwards, Wis.

"Work Scheduling for Emergency and Scheduled Shutdowns," by A. F. Richards, Champion Paper & Fibre Co., Hamilton, Ohio.

Discussion Session: Subject—"Corrosion in Economizers, Air Heaters, Fans, Ducts and Dust Collectors."

Drying and Ventilating

Program to be announced.

Mill Design and Economics

"Paper Mill Rehabilitation Involving Rebuilding an Old Paper Machine versus Installation of a New Machine (Part II) (speakers to be announced).

Electrical Engineering

"Pulp and Paper Mill Power Distribution, Part I," by S. A. Bobe, Westinghouse Electric Corp., 1299 Northside Drive, Atlanta, Ga.

"Paper Mill Lighting Design and Economics," by H. C. Swannell, J. E. Sirrine Co., Greenville, S. C.

Discussion Session: "Preventive Maintenance for Paper Mill Electrical Rotating Machinery," by N. L. Danforth, St. Regis Paper Co., Bucksport, Me.

"Commutation Problems of the Paper Mill," by D. E. Bivins, Jr., Brown Paper Mill Co., Monroe, La.

"Down Time of Electrical Sectional Drives," by R. F. Sorenson, Union Bag & Paper Co., Savannah, Ga.

Industrial Engineering

"Tomorrow's Methods Today (Automation)," by a representative of the Ford Motor Co., Detroit, Mich.

"Power Selection for Plant Industrial Trucks," Panel—J. M. MacBrayne, Union Bag & Paper Co., Savannah, Ga.; D. D. Hall, E. B. Eddy Co., Hull, P. Q., and W. A. MacKenzie, Everett Pulp & Paper Co., Everett, Wash. (for gas trucks); L. Carriker, Union Bag & Paper Co. (for electric trucks).

Chemical Engineering

"Notes on Liquor Circulation in Digesters," by J. E. Wilkinson, Champion Paper & Fibre Co., Canton, N. C.

"The Thermal Compression Evaporation of Spent Pulp Liquors; Its Application and Design in the Overall Heat Balance," by R. V. Kleinschmidt, Bowen Corp., 11 Union Rd., Cambridge 38, Mass.

Hydraulics

"Progress Report on TAPPI Research Project–Flow of Paper Stock in Pipes," by R. E. Durst, University of Maine, Orono, Me.

Mill Maintenance and Materials

"New Installations—Maintenance Work versus Contract Work," by E. L. Cowan, Bowaters Southern Paper Co., Calhoun, Tenn.

"Methods of Cleaning Rubber Covered Suction Press Rolls," by representative of Beloit Iron Works, Beloit, Wis.

Discussion Session: "Training Programs and Methods of Training Mill Maintenance Personnel," by E. J. Bartlett, Union Bag & Paper Co., Savannah, Ga., or Duncan C. Hunter, Ecusta Paper Co., Pisgah Forest, N. C.

Corrosion

"Digester Design to Reduce Corrosion"

"Digester Repair"

"Corrosion in Evaporators"

"Experiences with Digester Corrosion in a Mexican Pulp Mill"

Discussion Session: "What Can Digester Operators Do to Minimize Corrosion?"

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Professional Engineering Registration Laws

The Trustee Publication Fund, Jefferson City, Ohio, has issued a 614-page compendium of registration laws for professional engineers in 48 states, prepared by Alfred L. McCawley. It is prepared for professional engineers who plan to practice on a full or part time basis in another state or territory. The book can be purchased from the fund for $8.75. It presents, state by state, the exact legal requirements that must be met for professional practice.

Maine-New Hampshire

The Maine-New Hampshire Section will meet at Eastern Slope Inn, North Conway, N. H., on June 24–25, 1955. For persons arriving on June 23 there will be a social program.

On Friday morning, June 24, there will be a visit to the mills of the Brown Co. in Berlin, N. H. Ladies present will take the ski mobile ride up Cranmore Mountain.

At 2 p.m. the technical meeting will feature "Paper Machine Operating Problems."

Professor W. D. Howell of the University of Maine, Orono, Me., will present a paper on "Operating Problems of High Speed Tissue and Towel Machines."

Other papers will be presented by Samuel Bratton of Pusey & Jones Corp., Wilmington, Del.; A. E. Levensailor of the Great Northern Paper Co., Millinocket, Me.; Edward Beechler of Beloit Iron Works; S. A. Quist of Sandwell & Co. Ltd., Vancouver, B. C.; and George D. Bearce of the St. Regis Paper Co., Bucksport, Me.

At 4 p.m. there will be the annual meeting for the election of officers.

There will be a style show at 2:30 p.m. for the ladies.

The banquet will be held at 7 p.m. L. F. Whittemore, president of the Brown Co. will be the principal speaker.

On Saturday, June 25, the day will begin with a "Wake-em-Up breakfast."

At 9 a.m. the paper machine operation program will continue.

The social program on Saturday will include a golf tournament for men and women, an outdoor buffet lunch, an antiques auction, and a sports dinner.

The Local Arrangements Committee is composed of A. E. Jones, Oxford Paper Co., Rumford, Me.; J. F. Wright, National Aniline Division, Boston, Mass.; and H. E. Pratt, Pejepscot Paper Co., Brunswick, Me.

Clifford Patch, Eastern Corp., Bangor, Me.; J. J. Thomas, S. D. Warren Co., Cumberland Mills, Me.; and J. F. Wright are the members of the nominating committee.

R. J. Martin, Fraser Paper Ltd., Madawaska, Me.; J. H. Heuer, Great Northern Paper Co., Millinocket, Me., and Andrew J. Chase, University of Maine, Orono, Me., will be in charge of the technical program.

Sixth Testing Conference

The Sixth TAPPI Testing Conference will be held Sept. 28, 29, and 30, in Springfield, Mass., at the Sheraton-Kimball Hotel. The program will feature:

Reports of standing committee activities
A series of important papers on related subjects
Trips through some of the outstanding paper mills in the area
An exhibition of new testing and control instruments

The instruments to be exhibited will be ones that have new uses, that have been recently improved, or that are new to the paper industry.

New developments, faster machines, higher quality standards call for greater uniformity of quality, call for more and more effective control of quality. Before one can control one must first be able to measure. Through 13 standing committees (most of which have a number of subcommittees), the TAPPI Testing Division supplies the measurements—establishes the quality standards which enable this "art" industry to exercise such scientific control as is currently available.

It is not necessary to be a member of a testing committee in order to present a technical paper at the coming testing conference. Those having suitable material are requested to communicate with the Program Chairman, R. H. Simmons, U. S. Government Printing Office, Washington, D. C.

J. P. Casey, director of technical service for A. E. Staley Mfg. Co., is chairman of the Testing Division. He invites all interested TAPPI members to join the testing committee of their choice by merely writing to the committee chairmen. The standing testing committees and their chairmen are:

Fibrous Materials:	E. R. Schafer, Engineer, U. S. Forest Products Laboratory, Madison, Wis.
Nonfibrous Materials:	K. H. Williams, Chief Chemist. Mid-States Gummed Paper Co., 2515 S. Daman Ave., Chicago 8, Ill.
Wax:	G. C. Borden, Jr., Technical Director and Manager of Coating Dept., Riegel Paper Corp., Milford, N. J.
Pulp:	F. E. Caskey, Morden Machines Co., 3420 S. W. MacAdam Ave., Portland 1, Ore.
Optical Properties:	To be appointed. Persons interested in this committee should contact Mr. Casey.
Microscopy:	I. H. Isenberg, Research Associate, The Institute of Paper Chemistry, Appleton, Wis.
Paper:	L. Price, Government Printing Office, Washington 25, D. C.
Container:	M. Yezek, Manager Carton & Container Div., General Foods Co., Battle Creek, Mich.
Chemical Methods:	A. S. O'Brien, Supervisor, Paper Service Dept., Eastman Kodak Co., Kodak Park, Rochester 4, N.Y.
Bag:	A. R. Ewing, Laboratory Director, Bemis Bros. Bag Co., 40 Central St., Boston 9, Mass.
Boxboard:	M. W. Block, Quality Control Supervisor, Stone Container Corp., 4200 W. 42nd Place, Chicago 32, Ill.
Packaging Materials:	T. E. Dobbins, Supervisor, Non-Metallic Container Group, Research Div., American Can Co., Maywood, Ill.
Routine Control Methods:	E. E. Stephenson, Jr., Chemical Engineer, Sutherland Paper Co., Kalamazoo, Mich.

Mechanical Pulping Conference

Thomas F. LaHaise, Imperial Paper & Color Corp., Plattsburg, N. Y., general chairman, announces that plans are well in hand for the Second International Mechanical Pulping Conference to be held at Poland Spring, Me., Sept. 19–21, 1955.

Following is the program for the conference, which is to be jointly sponsored by the Technical Section, Canadian Pulp and Paper Association, and the Technical Association of the Pulp and Paper Industry.

Monday, Sept. 19, 1955

8:00 a.m. REGISTRATION

9:00 a.m. OPENING REMARKS
T. F. LAHAISE, Imperial Paper & Color Corp., Plattsburg, N. Y.

10:00 a.m. GENERAL SESSION
W. GALLAY, Director of Research, The E. B. Eddy Co., Hull, Que., *Chairman*

1. "The Potential of Groundwood," by W. Gallay.
2. "The Grinding Process—A Basic Approach," by D.

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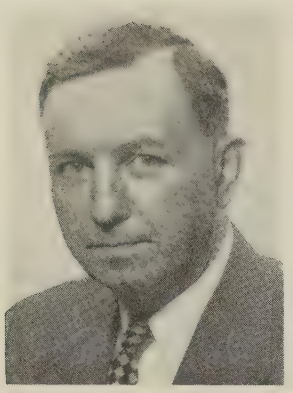
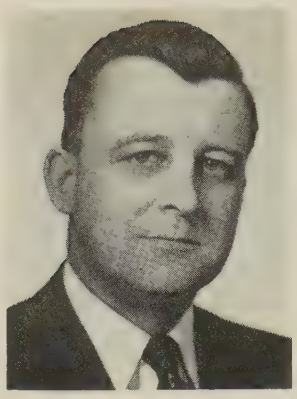


J. C. Pullman, American Cyanamid Co.; Chairman, Plastics Committee



T. F. LaHaise, Imperial Paper & Color Corp.; General Chairman, Mechanical Pulping Conference

Atack, Pulp and Paper Research Institute of Canada, Hull, Que.

3. "Pitless Grinding," by C. Anker, Risor Tremassefabrikker, Risor, Norway.

2:00 p.m. Wood Utilization Session

F. W. O'Neil, College of Forestry, State University of New York, Syracuse, N. Y., *Chairman*

1. "Conservation and Utilization of Wood for Mechanical Pulping," by R. W. Marquis, Northeastern Experiment Station, U. S. Dept. of Agriculture, Upper Darby, Pa.
2. "The Grinding of Pretreated Hardwoods," by A. Hyttinen and E. R. Schafer, Forest Products Laboratory, Madison, Wis.
3. "Commercial Production of Chemigroundwood for Newsprint," by J. H. Heuer, Great Northern Paper Co., East Millinocket, Me.

7:00 p.m. Banquet

Speaker: James L. Ritchie, Executive Director, United States Pulp Producers Association, New York, N. Y.—"The Groundwood Economy"

Tuesday, Sept. 20, 1955

9:00 a.m. General Session

1. "Groundwood Production Related to Fiber Technology," by K. Klemm, Anglo-Newfoundland Development Co., Grand Falls, Newfoundland.
2. "The Norton-Great Northern Research Stone," the Norton Co., Worcester, Mass.

10:30 a.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Printing and Specialty Papers.

2:00 p.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Board and Container Grades.

3:30 p.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Tissue and Toweling.

7:30 p.m. Refining Session

T. G. Rust, Quebec North Shore Paper Co., Baie Comeau, Quebec, *Chairman*

1. "Low Consistency Refining of Groundwood Rejects at Spruce Falls Power and Paper Co.," by R. H. Stafford and E. Gardiner, Spruce Falls Power & Paper Co., Kapuskasing, Ont.
2. "The Reisten Refiner," by E. F. Walsh, Anglo-Canadian Pulp and Paper Mills, Quebec, Que.

Wednesday, Sept. 21, 1955

9:00 a.m. Panel Discussion—Regional Techniques for the Production of Groundwood for Newsprint

2:00 p.m. Symposium—Cleaning and Bleaching

J. L. Parsons, Consulting Engineer, Waterville, Me., *Chairman*

Papers will be presented by mills where pressure-drop cleaning and bleaching of groundwood are being used to extend the use of groundwood papers into new fields.

Reservations for the conference should be addressed to Daniel Barry, resident manager, Poland Spring House, Poland Spring, Me. A ladies program, including golf, luncheons, and sightseeing trips, is also being planned.

The program for the conference is being prepared by John H. White, Keyes Fibre Co., Waterville, Me., and W. H. de Montmorency, Pulp and Paper Research Institute of Canada, Montreal, Que.

LETTERS TO THE EDITOR

Resin in Paper

To the Editor, *Tappi:*

Will you please clarify for me the following part of T 408 m-44 (Resin in Paper).

It is written "Extract at a rate of 15 siphonings per hour (which should yield a volume of 250 ml. per hour)."

We use the Soxhlet for resin and wax extractions and the siphon cup of same holds approximately 93 ml. This would make only 3 siphonings compared with 15 as specified and considering also that T 408 m-44 specifies 250 ml. per hour.

We have found that the number of siphonings is more important that the amount of solvent as far as results are concerned. Since we endeavor to adhere to the TAPPI standards we would appreciate your comments and advice.

Carl A. Anderson, *Research Div.*
Keyes Fibre Co., Waterville, Me.

To the Editor, *Tappi:*

The size of the Soxhlet extraction cup used by Mr. Anderson is considerably too large. Although the standard does not explicitly state the size, the Pyrex extraction tube No. 3820 would be satisfactory. This would give approximately 10 or 12 siphonings per hour since the volume of solvent required to fill the tube to the discharge point is 20 to 25 ml.

Mr. Anderson is correct in saying that the number of siphonings is more important than the total volume. It is therefore essential to use the smaller extraction cup and get approximately 10 to 15 siphonings per hour.

A. S. O'Brien, *Chairman*
TAPPI Chemical Methods Committee
Eastman Kodak Co.
Rochester, N. Y.

Cuprammonium Disperse Viscosity

To the Editor, *Tappi:*

In the TAPPI Standard (T 206 m-44) for Cuprammonium Disperse Viscosity of Pulp, there is a note stating that "The Hartman-Leddon Co., 6003 Girard Ave., Philadelphia, Pa., has prepared four mineral oil reference standards for the calibration of the viscosity tubes used in this method." A letter sent to this company has been returned unanswered. Can you tell us where we may obtain such reference standards

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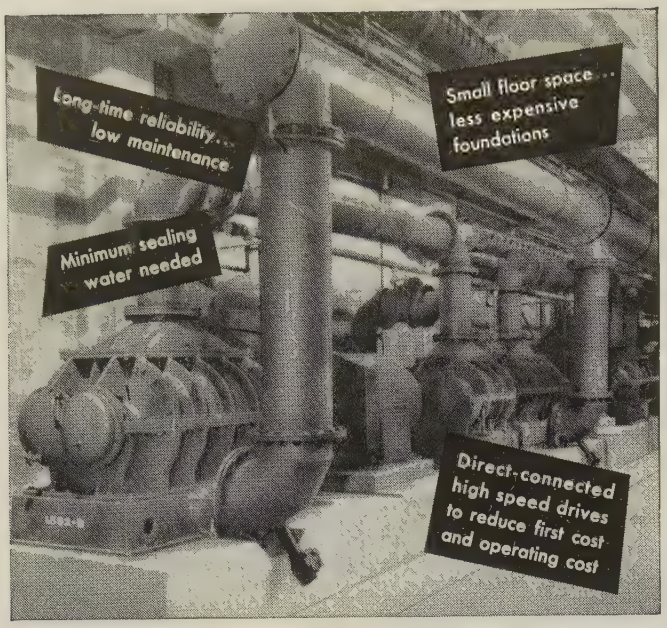
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at the present time? Can you also tell us where we may obtain viscosity tubes suitable for T 206 m-44?

ROBERT R. MCNARY, *Research Fellow*
Florida Citrus Commission
University of Florida
Lake Alfred, Fla.

To the Editor, *Tappi:*

A good supply of standard oils is now available from the National Bureau of Standards and the range involved in T 206 is adequately covered. The National Bureau of Standards puts out a circular giving oils available with the prices. It is shown in supplement to National Bureau of Standards Circular No. 398, or the information can be obtained by writing directly to the Bureau.

The viscosity tubes recommended to T 206 are ordinarily prepared by local glass blowers, following the dimensions given in the TAPPI standard. The apparatus may also be purchased from E. H. Sargeant & Co., Chicago, Catalogue No. S-65495.

A. S. O'BRIEN, *Chairman*
TAPPI Chemical Methods Committee

Phenyl Compounds in Food Packaging

To the Editor, *Tappi:*

In one of our projects we have encountered the question as to the danger of poisoning when adding phenyl mercuric acetate.

In this connection it is a question of manufacturing yellow strawboard (Dutch), which will probably later on be worked into corrugated board boxes or solid fiber boxes for the food industry.

I am specially interest to know, whether the American Government has prohibited the use of these mercury compounds for similar purposes.

F. MADSEN
Black-Clawson International
London, England

To the Editor, *Tappi:*

I know of no specific regulation regarding the use of phenylmercuric acetate or permissible residuals of this material in paperboard which may be used to package foods. There is however, a U. S. Public Health ordinance which states that no toxic material shall be used in manufacture of milk cartons which may be transferred to the food. In general, the paper manufacturers in the United States have restricted the use of mercurials in those grades of paper and paperboard which come in direct contact with food. In general, the U. S. Public Health ordinance is no different than those which apply to general dairy plant operations, use of sterilizing agents in food processing plants, etc. That is, the ordinance is general and applies to all foods and food industries. In essence the law states that no material shall be used in an amount which causes a toxic or potentially toxic residual in the food.

B. F. SHEMA, *Chief Microbiologist*
W. H. & L. D. Betz
Philadelphia, Pa.

Citrus Wraps

To the Editor, *Tappi:*

We should appreciate it if you would kindly inform this office as to what results have so far been obtained in the usage of diphenyl-treated paper in the wrapping of citrus fruits.

We should also appreciate your informing us if any inconvenience was brought to your attention in connection

with the use of said paper from the standpoint of public health.

MARCELLO EGIDI, *Commercial Consul*
Italian Consulate general
New York, N. Y.

To the Editor, *Tappi:*

We do not know of any current usage of diphenyl-treated citrus wrap in this country. Several years ago, a patent was issued to Crown Zellerbach on this subject matter, and for awhile they marketed such a product. More recently, however, many citrus fruits have been shipped in fiberboard boxes, thereby eliminating the need for individually wrapped fruits.

In so far as the effectiveness of diphenyl against blue mold and stem-end rot is concerned, we believe that most people would agree that it is probably more specific in its control of these "diseases" than any of the other fungicides which are presently available for this purpose.

The public health aspects of diphenyl have been studied rather extensively, both in this country and abroad. Work is still going forward and final conclusions have not yet been reached. Like most materials, diphenyl can be "toxic" if present in sufficient quantities. The "threshold" toxicity is, however, quite low and from a practical standpoint, there are many who feel that there may be no public health problem. This is a subject, however, which is yet to be resolved and we do not wish to take a position on it at this time.

JOHN G. STRANGE, *Vice-President*
The Institute of Paper Chemistry
Appleton, Wis.

To the Editor, *Tappi:*

In reference to diphenyl-treated papers for citrus wraps the following references are of interest:

A paper by R. G. Tomkins, "Wraps for the Prevention of Rotting Fruit," Dept. Sci. Ind. Research (Brit.) Rept. Food Invest. Board 1935, reports on about 100 compounds for effectiveness in controlling green mold on citrus fruits and finds diphenyl the most effective.

U. S. pat. 2,173,453 (Sept. 19, 1949) covers impregnation of fruit wrappers with mineral oil containing diphenyl, and U. S. pat. 2,265,522 (Dec. 9, 1942) describes a process for treating paper with diphenyl mixed with an inert gaseous medium for the prevention of molding of citrus fruits.

Other references of interest in this connection are:

Hopkins, E. F., and Loucks, K. W., Use of Biphenyl in the Control of Stem-End Rot and Mold in Citrus Fruit. *Citrus Ind.* 28, No. 10: 5–9 (1947); *C. A.* 42: 2383i (1948).

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Anon., Corrugated Citrus Box. *Modern Packaging* 23, No. 12:98-100 (1950).

Anon., Wrappers for Citrus Fruit. *World Paper Trade Rev.* 133, No. 13:876 (1950).

Tomkins, R. G., Treated Wraps for the Prevention of Rotting. *Dept. Sci. Ind. Research (Brit.), Rept. Food Invest. Board* 1936: 149-51 (1937); *C. A.* 32:55215 (1938).

Van der Plank, J. E., and Rattray, J. M., The Use of Wraps Impregnated with *o*-Phenyl Phenol Against Decay in Oranges. *Union S. Africa, Dept. Agr. & Forestry, Rept. Low-Temp. Research Lab.* 1937–38: 142-145 (1939); *C. A.* 34:29464 (1940).

Barber, W. R., Natwick, A. G., and Phelps, M. W. (to Crown Willamette Paper Co.), Copperized Paper. U. S. pat. 1,947,451 (Feb. 20, 1934).

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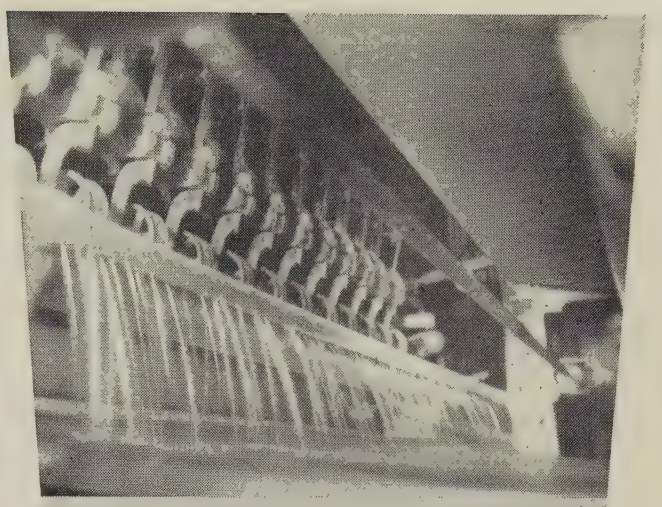

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

William D. Andrew, Machine Tender, Container Corp. of America, Wilmington, Del.

Alexander Babin, Chief Development Engineer, Solo Cup Co., Chicago, Ill., a 1937 graduate of the Mittweida Engineering School, Germany.

Joseph E. Bajek, Chemist, Morningstar Nicol, Inc., New York, N. Y., a 1952 graduate of New York University.

James P. Bambacht, Student, The Institute of Paper Chemistry, Appleton, Wis., a 1954 graduate of Kalamazoo College.

Jean Barbut, Consulting Engineer, Paris, France, a graduate of the Polytechnic College.

William L. Baumner, Jr., Vice-President, Pioneer Chemical Works, Inc., Philadelphia, Pa., a 1941 graduate of the Philadelphia Textile Institute.

Andrew, T. Bavelas, Assistant Superintendent, Monadnock Paper Mills, Inc., Bennington, N. H.

Mrs. Sydney Berner, Librarian, Herman Wolf Associates, New York, N. Y.

Georges E. Breton, Technical Director, Societe des Papeteries Aubry, Croisset les Rouen, France, a graduate of Ecole Francaise de Papeterie.

Harry S. Blumberg, Chief Metallurgist, M. W. Kellogg Co., Jersey City, N. J., a 1915 graduate of Crane Junior College.

Donald A. Borden, Sales Engineer, Bauer Bros. Co., Springfield, Ohio, a 1942 graduate of Tri-State College.

John Bryce, Chemist, Howard Smith Paper Co., Cornwall, Ont., Canada, a 1955 graduate of McGill University with a Ph.D. degree.

Francis V. Calvert, President and General Manager, Gran-Cal, Inc., Rocky River, Ohio, a 1919 graduate of Ecole Navale, Brest, France.

Allen E. Chittenden, Senior Experimental Officer, Colonial Products Laboratory, London, England, a graduate of the University of Reading and London School of Printing.

David O. Chua, Student, University of Maine, Orono, Me., a 1953 graduate of the University of Santo Tomas.

Walter R. Cloud, Manager, U. S. Paper Mills Corp., W. DePere, Wis. Attended the University of Wisconsin.

Earl J. Crow, Assistant to Statistical Quality Control Supervisor, Minnesota & Ontario Paper Co., International Falls, Minn., a 1950 graduate of the College of St. Thomas.

Lionel A. Cox, Director of Research, Johnson & Johnson Ltd., Montreal, P. Q., Canada, a 1946 graduate of McGill University with a Ph.D. degree.

Paul F. Cundy, Supervisor of Technical Service, Marathon Corp., Menasha, Wis., a 1939 graduate of the University of Illinois with a Ph.D. degree.

Frederick W. Davis, Trainee, Weyerhaeuser Timber Co., Pulp Div., Tacoma, Wash., a 1951 graduate of Yale University.

H. J. A. de Goeij, President, DeSpaarnestad Printers and Publishers, Haarlem, The Netherlands, a 1926 graduate of Delft Polytechnical University with a Ph.D. degree.

William H. Detwyler, Technical Supervisor, Container Corp. of America, Wilmington, Del. Attended Lafayette College.

Lowes E. De Weese, Sales Engineer, Patton Mfg. Co., Springfield, Ohio, a 1924 graduate of Yale University.

Anne S. Dickens, Technical Librarian, Pitney-Bowes, Inc., Stamford, Conn., a 1949 graduate of the University of Kentucky.

Gordon L. Dickson, Assistant Chief Chemist, Gilman Paper Co., Gilman, Vt., a 1950 graduate of the University of Bishops College.

Fred A. Dieckbrader, Manager, Pulp and Paper Mills, Hinde & Dauch Paper Co. of Canada Ltd., Toronto, Ont., Canada.

Charles Draeger, General Manager, Draeger Freres, Montrouge (Seine), France.

Ronald A. Dyke, Plant Engineer, International Paper Co., Niagara Falls, N. Y., a 1940 graduate of the University of Maine.

John E. Easterbrook, Librarian, Imperial Oil Ltd., Sarnia, Ont., Canada, a 1927 graduate of McGill University.

Ernest F. Eastman, Jr., Chemist, E. I. du Pont de Nemours & Co., Penn's Grove, N. J., a 1951 graduate of the University of Notre Dame.

Carl H. Eisenmenger, Mill Manager, The Sorg Paper Co., Middletown, Ohio.

Donald W. Ferguson, Student, New York State College of Forestry, Syracuse, N. Y., a 1951 graduate of Niagara University.

William G. Filmyer, Salesman, Pioneer Chemical Works, Inc., Philadelphia, Pa. Attended Philadelphia Textile Institute.

Joseph E. Foster, Vice-President, Schiffenhaus Bros., Newark, N. J.

Ronald G. Foxall, Development Engineer, Canadian Forest Products Ltd., Port Mellon, B. C., Canada, a 1952 graduate of the University of British Columbia.

Naohisa Fukushima, Chief of Laboratory, Kindat Karaku Kogyo Co., Inc., Osaka, Japan, a 1943 graduate of Kyoto Pharmaceutical College.

Richard T. Galganski, Supervisor, Process Engineering, Marathon Corp., Rothschild, Wis., a 1940 graduate of the University of Wisconsin.

G. Ives Gehring, Manager, Pulp and Paper Div., Oswego Falls Corp. and Sealright Co., Inc., Fulton, N. Y., a 1931 graduate of New York State College of Forestry.

Albert G. Gibson, Assistant General Manager, Bagley & Sewall Div., The Black-Clawson Co., Watertown, N. Y. Attended Kansas University.

Robert Gordon, Quality Supervisor, National Gypsum Co., Garwood, N. J., a 1950 graduate of Newark College of Engineering.

William C. Grater, Senior Statistician, Bowaters Southern Paper Corp., Calhoun, Tenn., a 1949 graduate of Montana State University.

Paul C. Hanson, Jr., Chemist, Hollingsworth & Whitney Div., Scott Paper Co., Mobile, Ala., a 1949 graduate of Wheaton College.

Robert B. Hay, Plant Engineer, Keyes Fibre Co., Waterville, Me., a 1943 graduate of the University of Maine.

Charles T. Hightower, Technical Director, International Paper Co., Natchez, Miss., a 1936 graduate of Alabama Polytechnic Institute.

Roy W. Hodgkinson, Chief Chemist, The Thompson &

Norris Mfg. Co. Ltd., Brentwood, Middlesex, England. Attended Imperial College, London.

H.'t Hooft, President, N. V. Noordelijke Industrie voor Vezelverwerking, Hoogezand, The Netherlands, a 1922 graduate of the Technical University at Delft.

James L. Horton, Technical Superintendent, Diamond Match Co., Ogdensburg, N. Y., a 1949 graduate of Clarkson College.

Nathan R. Hower, Contracting Engineer, Chicago Bridge & Iron Co., New York, N. Y., a 1936 graduate of the University of Alabama.

James K. Hubbard, Technologist, Weyerhaeuser Timber Co., Longview, Wash., a 1950 graduate of Oregon State College with a Ph.D. degree.

Irvin D. Hummel, Mechanical Engineer, Herman N. Simpson Consultants, Seattle, Wash., a 1950 graduate of the University of Washington.

Allen B. Hunter, Field Engineer, Alchem Ltd., Montreal, P. Q., Canada, a 1950 graduate of the University of Toronto.

Isao Imazu, Chief Chemical Engineer, Yodogawa Works, Kanegafuchi Spinning Co. Ltd., Osaka, Japan, a 1933 graduate of Kanazawa Technical College.

Herbert F. Jacques, Technical Director, Vanity Fair Paper Mills, Inc., Plattsburg, N. Y., a 1932 graduate of Georgetown University.

Godfrey M. James, Jr., Research Chemical Engineer, Robert Gair Co., Inc., Uncasville, Conn., a 1952 graduate of the University of Pennsylvania.

Daniel R. Jimenez, Chemical Engineer, Compania de las Fabricas de Papel de San Rafael y Anexas S. A., Mexico, D. F., Mexico, a 1951 graduate of the University of Mexico.

Rune Johansson, Sales Manager, Elof Hansson, Gothenburg, Sweden. Attended the Institute of Commerce, Gothenburg.

Donald E. Johnson, Technical Assistant, St. Regis Paper Co. Deferiet, N. Y.

Lloyd K. Johnson, Vice-President, Superwood Corp., Duluth, Minn., a 1931 graduate of the University of Minnesota.

Robert J. Keating, Manager, Industrial Waste Treatment Dept., New York, N. Y., a 1941 graduate of the Michigan College of Mining and Technology.

Louis K. Keay, Engineer, Lukens Steel Co., Coatesville, Pa., a 1946 graduate of Pennsylvania State College.

Theodore R. Kielts, Research Paper Technologist, AC Spark Plug Div., General Motors Corp., Flint, Mich., a 1952 graduate of Western Michigan College.

Robert E. Kinsey, General Manager, Gardiner Paper Mills, Inc., Gardiner, Me., a 1934 graduate of the University of Toledo, Ohio.

Lyn Koffel, Salesman, Pioneer Chemical Works, Inc., Philadelphia, Pa. Attended the University of Nebraska.

Harry Kroll, Research Director, Alrose Chemical Div., Geigy Chemical Corp., Providence, R. I., a 1942 graduate of the University of Chicago with a Ph.D. degree.

Harold M. Lacey, Control Laboratory Supervisor, The Ontario Minnesota Pulp & Paper Co. Ltd., Kenora, Ont., Canada, a 1944 graduate of the University of Saskatchewan.

John L. Lewis, Technical Sales and Service, Hercules Powder Co., Wilmington, Del., a 1950 graduate of Cornell University.

Martin R. Leven, Chief Chemist, Lincoln Paper Co., Chicago, Ill., a 1951 graduate of Michigan State College.

Alfred R. Major, Chief Engineer, St. Regis Paper Co., Pensacola, Fla., a 1937 graduate of the University of Florida.

John B. Martin, Chief Chemist, Central Research Dept., Crown Zellerbach Corp., a 1933 graduate of the University of Chicago.

Kedwick R. Martin, Quality Control Engineer, Fort Wayne Corrugated Paper Co., Hartford City, Ind., a 1944 graduate of New York University.

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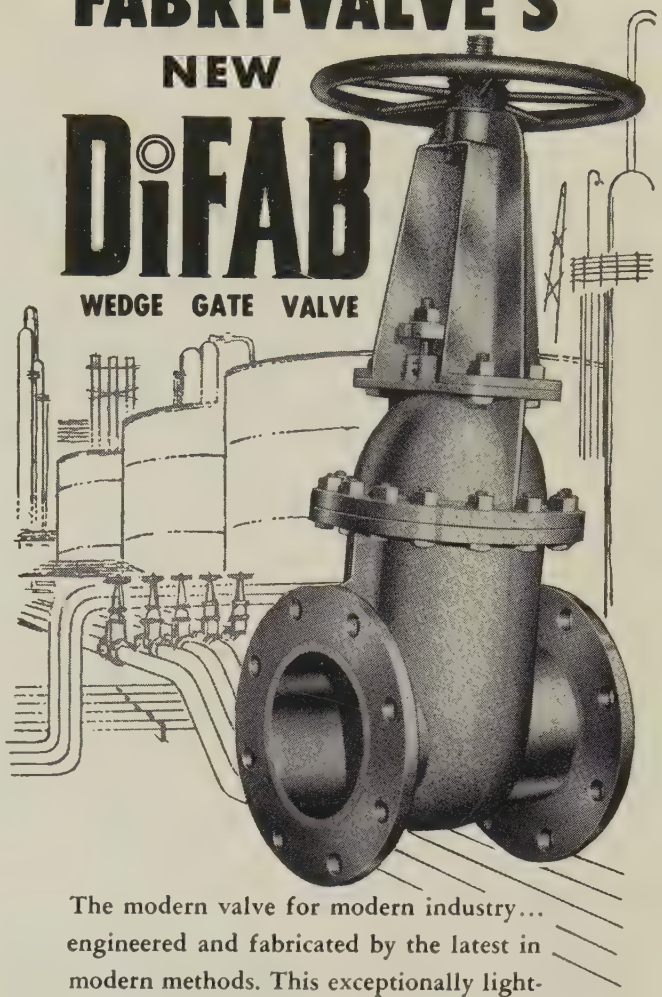

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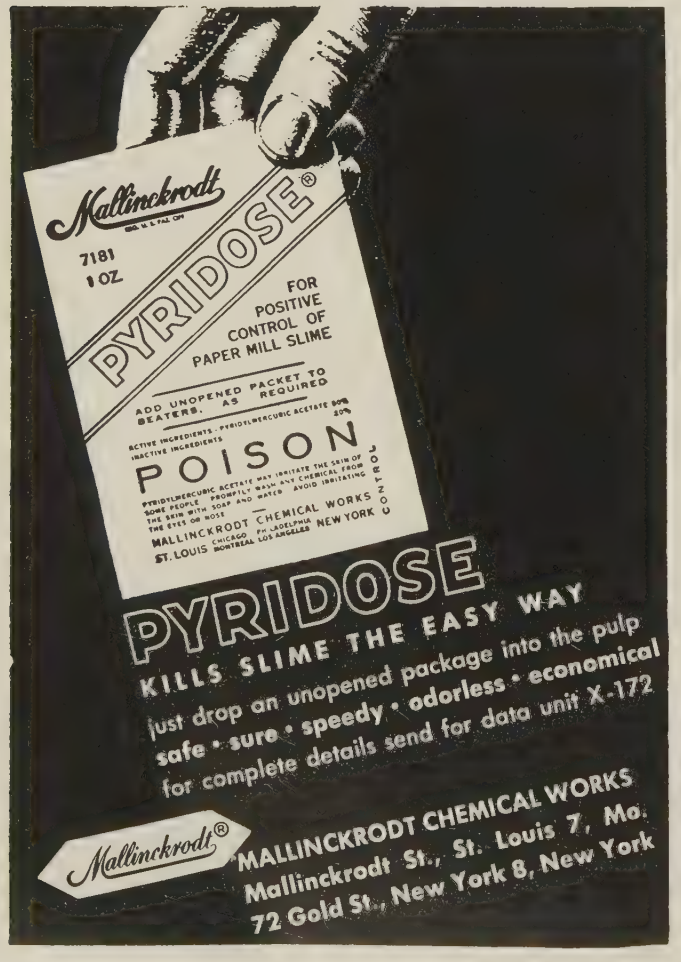
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Maurice D. Mathieu, Chemist, Oxford Paper Co., Rumford, Me. (on leave of absence with U. S. Army). A 1954 graduate of Colby College.

Robert D. McPheters, Control Superintendent, St. Croix Paper Co., Woodland, Me., a 1941 graduate of the University of Maine.

Manuel R. Monsalud, Chief Chemist, Forest Products Laboratory, Philippine Bureau of Forestry, College, Laguna, P. I., a 1931 graduate of the College of Agriculture.

Theodore L. Moore, Supervising Sanitary Engineer, Gibbs & Hill, Inc., New York, N. Y., a 1930 graduate of Nebraska Central College.

Robert W. Nerenberg, Director of Research, The Interstate Folding Box Co., Middletown, Ohio, a 1947 graduate of the University of Cincinnati.

G. Sanchez Perez, Assistant Mill Manager, Compania de las Fabricas de Papel de San Rafael y Anexas S. A., Mexico, D. F., Mexico, a 1941 graduate of the University of Mexico.

La Fayette Price, Paper Chemist, U. S. Government Printing Office, Washington, D. C.

Stanley E. Price, Plant Engineer, Marinette Paper Co., Fort Edward, N. Y., a 1941 graduate of Drexel Institute of Technology.

William A. Pritchett, Draftsman, The Sorg Paper Co., Middletown, Ohio, a 1938 graduate of the West Virginia Institute of Technology.

Gordon A. Rabeler, Chemical Engineer, International Paper Co., Glens Falls, N. Y., a 1948 graduate of Rensselaer Polytechnic Institute.

Jack H. Reid, Technical Sales, American Cyanamid Co., New York, N. Y., a 1950 graduate of the University of Mississippi.

Julius C. Rosenberg, Assistant Manager, O. G. Kelley & Co., Boston, Mass. Attended Boston University.

Desmond T. Roy, Assistant Manager, Pulp Development and Pilot Plant, Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada, a 1948 graduate of the University of Toronto.

John J. Samsel, Assistant Manager, Graver Water Conditioning Co., New York, N. Y., a 1949 graduate of Villanova College.

Jorge R. Sanguinetti, Trainee, Fabrica Nacional de Papel, Montevideo, Uruguay.

Thomas J. Scanlon, Sales, W. H. & F. Jordan, Jr., Mfg. Co., Philadelphia, Pa., a 1939 graduate of Lowell Technological Institute.

Joseph W. Schiffenhaus, President, Schiffenhaus Bros., Newark, N. J., a 1923 graduate of Dartmouth College.

Louis A. Schlapfer, Jr., Chemist, E. I. du Pont de Nemours & Co., Newark, N. J., a 1939 graduate of Georgia Institute of Technology.

Herbert K. Schmidt, President and Owner, ER-WE-Pa, Dusseldorf, Germany.

William F. Schmidt, Salesman, National Aniline Div., Allied Chemical & Dye Corp., New York, N. Y., a 1947 graduate of Purdue University.

Joseph Schneider, Plant Engineer, A & P Corrugated Box Corp., Lawrence, Mass., a 1949 graduate of Massachusetts Institute of Technology.

Mineard E. Schuler, Chief Physical Tester, Champion Paper & Fibre Co., Hamilton, Ohio.

Jean Sinai, Pulp and Paper Consultant, Paris, France, a graduate of the University of Paris, Faculty of Sciences.

Lloyd E. Stevenson, Assistant Industrial Relations Manager, Fibreboard Products, Inc., San Francisco, Calif., a 1935 graduate of Oregon State College.

Kenneth W. Sulser, Chemical Engineer, West Virginia Pulp & Paper Co., Luke, Md.

Roy S. Swenson, Research and Control Engineer, Great Northern Paper Co., Millinocket, Me., a 1954 graduate of New York State College of Forestry.

Roger E. Thorkildsen, Student, New York State College of Forestry, Syracuse, N. Y.

Gordon A. Trainham, Superintendent, Brown's Island Mill, Albemarle Paper Mfg. Co., Richmond, Va.

Hiroshi Uchiyama, Head of Unit Research, Toyo Rayon Co., Ehime Factory, Ehime-Ken, Japan, a 1944 graduate of Kyoto University.

Edward E. Uehlein, Paper Mill Project Engineer, Marinette Paper Co., Marinette, Wis., a 1948 graduate of the University of Wisconsin.

Blair R. Utter, Assistant Superintendent No. 1 Mill, Champion Paper & Fibre Co., Hamilton, Ohio.

Roy Wallace, District Manager, Goodyear Chemical Div., Cleveland, Ohio, a 1948 graduate of Ohio State University.

Herbert J. Ward, Sales Engineer, Bumstead-Woolford Co., Seattle, Wash., a 1941 graduate of U. S. Naval Academy.

Leslie E. Wandorf, Paper Mill Engineer, Marinette Paper Co., Fort Edward, N. Y., a 1950 graduate of Purdue University.

Robert E. Whitney, Technical Salesman, Hercules Powder Co., Chicago, Ill., a 1947 graduate of the University of Minnesota.

Lars G. Wiklund, Technical Manager, Tako Board Mill, G. A. Serlachius Oy, Tammerfors, Finland, a 1946 graduate of the Technical University of Finland.

Joseph Winterburn, Managing Director, Joseph Winterburn Ltd., Bury, Lancs., England, a graduate of the Manchester College of Technology.

Shuichiro Yasuda, Chief, Stock Preparation Section, Daishoa Paper Mfg. Co. Ltd., Fuji City, Shizuoka Pref., Japan, a 1942 graduate of Kyoto University.

TAPPI Notes

Raymond E. Baker is now Manager of Manufacture of the Pulp Division, Weyerhaeuser Timber Co., Tacoma, Wash.

George E. Clink is now Chief Engineer of the Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.

Stanley W. Hoyman, formerly of Central States Engineering Inc., is now Paper Mill Engineer for the Marathon Corp., Menasha, Wis.

Charles E. Elliott, formerly a student at Western Michigan College, is now a Technologist for The Champion Paper & Fibre Co., Pasadena, Tex.

Dwayne J. Clark, is now Technical Superintendent of The Simpson Logging Co., Div. of The Everett Pulp & Paper Co., Everett, Wash.

George H. Spencer of The Torrington Co. has been transferred from Torrington, Conn., to South Bend, Ind.

Carl H. Allendorf, formerly of The Philip Carey Mfg. Co., is now a partner in C. H. Allendorf Associates, Engineers, Lockland, Ohio.

Robert R. Buss, of The Hercules Powder Co. has been transferred from Wilmington, Del., to Kalamazoo, Mich., as Acting Manager of the branch sales office.

John E. Cleary, formerly of the St. Lawrence Paper Co., is now Chief Chemist of The Black River Kraft Div., St. Regis Paper Co., Deferiet, N. Y.

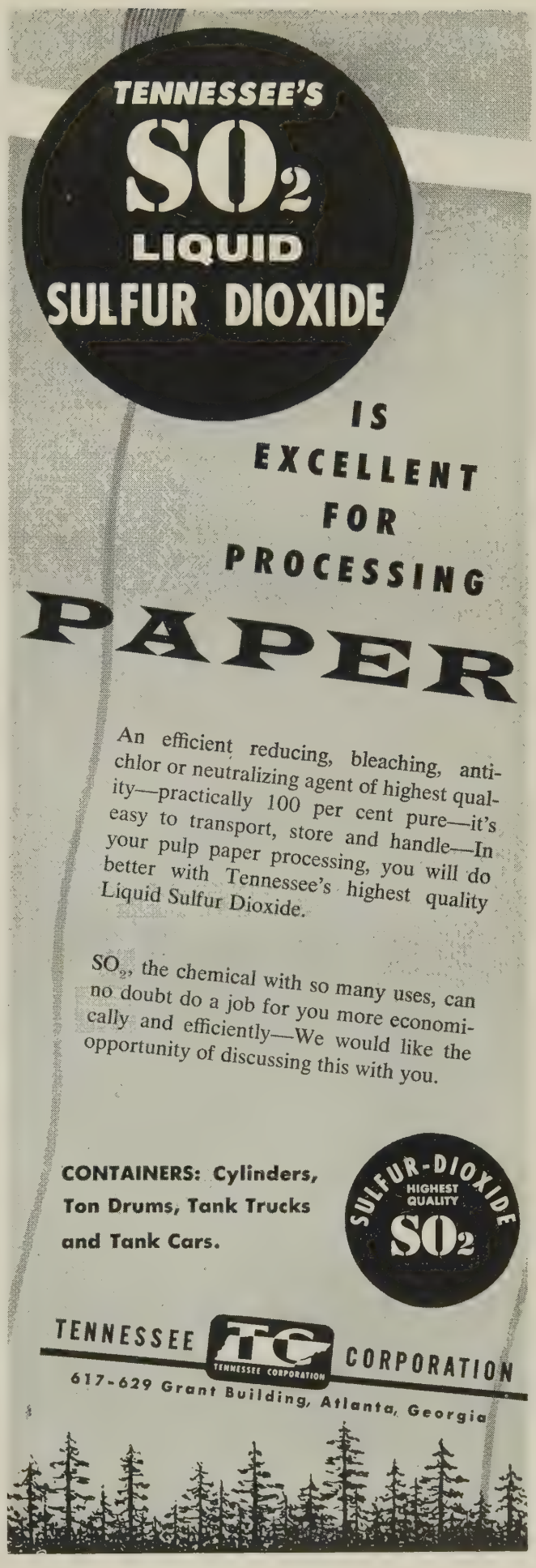
Sidney M. Collier, formerly of The Metal Sales Co., is now Vice-President of the Pulp Bleaching Co., Inc., Seattle, Wash.

Robert De S. Couch is now Manager of The Carton & Container Div., General Foods Corp., Battle Creek, Mich.

John E. Dain, formerly of The Cameron Machine Co., is now in the Sales Dept. of The Dilts Machine Co., Fulton, N. Y.

C. B. Davies, formerly of The Irving Pulp & Paper Co., is now Manager of The Paper Machinery Div., John Inglis Co. Ltd., Toronto, Ont.

Marshall De Cew, formerly of Oliver-United Corp., is now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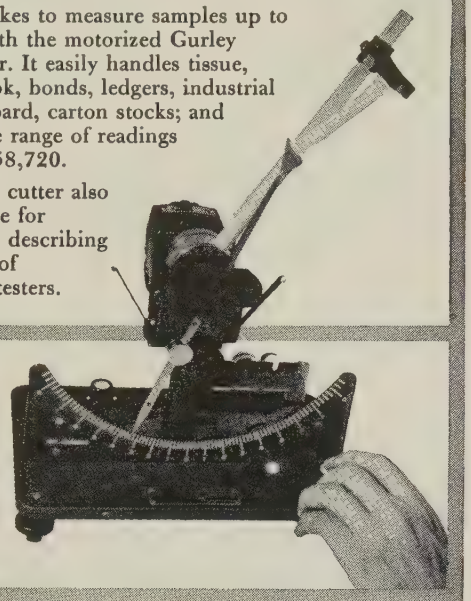

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Executive Sales Engineer for Pandia, Inc. Div., Black-Clawson Co., New York, N. Y.

Fred B. Doherty, is now General Manager for southeastern cellulose manufacture of Rayonier, Inc., Fernandina, Fla.

Hervey R. Emery, Jr., Steam Engineer for The St. Regis Paper Co., has been transferred from Deferiet, N. Y., to Jacksonville, Fla.

Norman S. Eppell, formerly of the Q.M. Food & Container Institute, is now Branch Engineer for The Ordnance Ammunition Command, Joliet, Ill.

Paul J. Frost, formerly of The Oregon Pulp & Paper Co., is now a Project Engineer in the Central Research & Development Laboratories of Crown Zellerbach Corp., Camas, Wash.

Philip H. Goldsmith, formerly of The Pusey & Jones Corp., is now Sales Manager for The Dominion Engineering Works, Ltd., Montreal, P. Q.

Ronald G. Goodwin is now Sales Manager of Pandia, Inc. Div. of Black-Clawson Co., New York, N. Y.

Blanton W. Haskell is now Assistant Resident Manager in Charge of Engineering and Maintenance for Rayonier, Inc., Jesup, Ga.

Fred Herbolzheimer, Jr., is now Production Manager of Marinette Paper Co., Marinette, Wis.

Philip H. Hershey is now Technical Director of P. H. Glatfelter Co., Spring Grove, Pa.

Raymond A. Hill, Jr., is now Assistant to the Plant Manager of Congoleum-Nairn, Inc., Cedarhurst, Md.

John G. Hood, of John G. Hood & Associates has moved his offices from Ann Arbor, Mich., to Yipsilanti, Mich.

Waldemar Jensen of The University of Abo (Finland) is now also Director of The Research Laboratories of The Finnish Pulp & Paper Industries, succeeding Bertil Nybergh (deceased).

Burt L. Kassing is now Manager of the Production Planning Dept., Nekoosa-Edwards Paper Co., Port Edwards, Wis.

W. O. Kincannon, Jr., Technical Service Engineer of The Hercules Powder Co., has been transferred from Wilmington, Del., to New Orleans, La.

Milos Krofta, formerly of The Ancram Paper Mills, has organized the Krofta Engineering Co. in Lenox, Mass.

Bernard J. Koziol, formerly Plant Engineer of The St. Regis Paper Co., is now with The Avery Corp., Fiber Forming Div., Olean, N. Y.

Robert B. LeRoy of The Bemis Bros. Bag Co. has been transferred from East Pepperell, Mass., to Minneapolis, Minn., as Manager of The Tekmold Products plant.

John A. MacArthur, formerly Chief Engineer of Brompton Pulp & Paper Co., has established a Consulting Engineering partnership in Montreal, P. Q., with Alfred Malkin and James E. Daly.

John M. McClure, formerly of Potlatch Forest, Inc., is now in Production Development for the West Virginia Pulp & Paper Co., Charleston, S. C.

Robert F. McDonnell, formerly Plant Manager of The Standard Paper Mfg. Co., is now with The International Paper Co., Livermore Falls, Me.

Harold C. Macklem, formerly of The St. Regis Paper Co., is now an Engineer with J. E. Sirrine Co., Greenville, S. C.

Malcolm N. May, formerly with the Champion Paper & Fibre Co., is now a Research Assistant at The Institute of Paper Chemistry, Appleton, Wis.

Thomas S. Morse is now Manager of Sales Service for The Hercules Powder Co., Wilmington, Del.

Robert F. Nelson, formerly Vice-President of The Rhinelander Paper Co., is now General Manager of The Sales Department of The Shellman-Betner Div., Continental Can Co., Mt. Vernon, Ohio.

P. F. Newmann is now Manager of Rosin Size Sales for The Hercules Powder Co., Wilmington, Del.

William J. O'Brien is now President of O'Brien Steam Specialties Co., Syracuse, N. Y.

Richard W. O'Donnell, formerly of The St. Regis Paper Co., is now Chemist for The Halifax Paper Co., Roanoke Rapids, N. C.

Arthur Patureau, Sales Engineer for The Pennsylvania Industrial Chemical Corp., has been transferred from Clairton, Pa., to Los Angeles, Calif.

J. C. Pullman is now Manager of Technical Service for The Petrochemicals Dept. of American Cyanamid Co., New York, N. Y.

Lucien G. Rolland is now President of The Rolland Paper Co., St. Jerome, P. Q.

Marc Rolland, is now Vice-President and Manager of Mills of The Rolland Paper Co., St. Jerome, P. Q.

Robert L. Schuerman is now Assistant Manager of Industrial Sales in Charge of Sales to the Paper and Corrugating Industries for A. E. Staley Mfg. Co., Decatur, Ill.

Joseph J. Schwenkler is now Technical Superintendent of The Folding Carton Div., Container Corp. of America, Philadelphia, Pa.

Russell G. Seip, formerly Chief Engineer of The St. Regis Paper Co., has retired and is now a Consultant in New York City and Pensacola, Fla.

Alvin H. Sinclair is now Assistant Director of the Paper Chemical Application Laboratory, American Cyanamid Co., Chicago, Ill.

Joseph M. Theberge is now Dyestuffs Chemist for The Merrimac Paper Co., Lawrence, Mass.

Carl A. von Ende, formerly of The Gilman Paper Co., is now Manager of The Cascade Mill, Brown Co., Berlin, N. H.

Elliott H. Woodruff is now Acting Assistant Resident Manager of Rayonier, Inc., Port Angeles, Wash.

Cam F. Vozar, formerly of The Paper Converting and Finishing Co., is now Plant Engineer of McLaurin-Jones Co., Homer, La.

Henry Vranian is now Vice-President and Sales Manager of The Chesapeake Corp., West Point, Va.

Lawrence T. Waterman, General Manager of The St. Regis Paper Co., has been transferred from Deferiet, N. Y., to Carthage, N. Y.

E. N. Wennberg is now Manager of The Pulp Division Mills, Weyerhaeuser Timber Co., Longview, Wash.

Hugo G. Zwecker, formerly of Papierfabrik Wattens (Austria), is now with the J. O. Ross Engineering Co., Los Angeles, Calif.

* * *

H. M. Pier, official representative of Research-Cottrell, Inc. in TAPPI, has moved his office from Bound Brook, N. J., to New York City.

Vernon Woodside has succeeded *G. P. Vincent* as the official representative of Olin Mathieson Chemical Corp. in the Technical Association. Mr. Woodside is New Orleans, La., District Sales Manager.

The Moore & White Co. has moved its plant to 330 E. Hunting Park Ave., Philadelphia, Pa.

Industry Notes

PRODUCTION

The paper industry, having concluded 1954 with such strength that a new record of 26,657,000 tons was established, began the new year in a more subdued manner as an estimated 2,063,000 tons were manufactured. This was about 5% less than in December and, unless revised upward when the final figures for the month become available, will also have been lower by about 5% than the output of January, 1953 and 1954, respectively.

The January output of printing paper (exclusive of newsprint) is estimated to have been 273,000 tons, 6% less than in December, and lower than for any individual month in 1954, except July. The volume of new orders exceeded shipments

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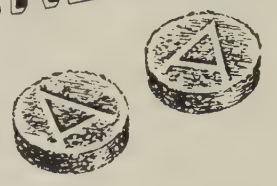

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4 Rapidly soluble

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2,000 tablets to a carton
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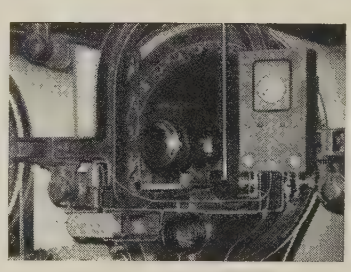

New Stickle System Maintains Exact Moisture Content Desired . . . Restores Proper Moisture Content After Breaks Up to 8 Times Faster

Now in operation at leading mills, the new Stickle Pres-Ten-Trol automatically maintains exact moisture content desired within 0.5% . . . restores proper moisture content after breaks up to 8 times faster than former methods. Records or indicates moisture variation of sheet and steam pressure in dryers . . . eliminates time-consuming hand adjustment of steam flow to dryers . . . cuts steam consumption . . . reduces customer complaints. Get the facts on how to end your moisture control problems . . . in Stickle bulletin 360-C.

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Total Production and Wastepaper Recovery 1951–1954

	1951	1952	1953	1954
Population of U. S.	154,353,000	155,767,000	159,696,000	162,414,000
Total U. S. production of paper and paperboard	26,048,000	24,413,000	26,566,000	26,657,000
Total imports to U. S. of paper and paperboard	5,139,254	5,173,352	5,212,851	5,169,000
Total production and imports of paper and paperboard	31,187,254	29,586,353	31,778,851	31,826,000
Total exports of paper and paperboard	527,895	498,111	475,990	590,503
Total U. S. consumption of paper and paperboard	30,659,357	29,088,241	31,302,861	31,235,497
Average per capita consumption, paper, and paperboard, lb.	397.2	373.5	392	384.6
Wastepaper, total salvaged	9,458,438	7,959,815	8,540,746	8,151,858
Ratio of recovery of wastepaper to consumption of paper and paperboard, %	30.8	27.3	27.3	26.1

Except for population, all above figures in short tons unless specified otherwise.

by about 28,000 tons, causing unshipped or unmade orders to rise to 325,000 tons, their highest level since March of 1954.

Although fine paper production at 115,000 tons was down slightly from the December level, the January output of these papers was above that achieved during the same month in 1953 and 1954, exceeding the output of those months by about 10 and 12%, respectively. The volume of new orders was slightly less than that of shipments, but the tonnage represented by unshipped or unmade orders continued at approximately 62,000 tons.

As in the instance of printing papers, estimated coarse paper production for January was lower than that for any month in 1954 except July. Production for the month, estimated to have been 260,000 tons, was 19,000 tons less than in December. The tonnage represented by new orders, although slightly more than shipments during the month, was 23,000 tons below the volume of new orders received in December.

For tissue paper, both production and shipments were higher than in December by about 5 and 13%, respectively. However, while January production of 124,000 tons represented an advance over the preceding month, output for that month was about 8% less than for the same month last year. The volume of new orders, at 128,000 tons, although below a year ago, exceeded that of November and December and approximated the monthly average during 1954.

The production of newsprint continued its steady improvement as production for the month rose to 116,000 tons, a record high for recent years.

The output of paperboard in January dipped slightly to 917,000 tons, 6% less than in December and 7% below that of the preceding January. The volume of new orders received although slightly less than in December, exceeded production and unfilled orders at the close of the month were 321,000 tons.

Wood Pulp

The continuous high rate of paper and board production and the sharp increase in exports, were the two principal factors enabling the pulp mills to reach a record high production of 18,341,000 tons last year. Compared to the previous year, this was an increase of 804,000 tons. Approximately 30% of this increase can be attributed to the increase in exports.

Consumption of wood pulp also reached record proportions for the year. Last year consumption totaled 19,034,000 tons, an increase of 353,000 tons over 1953.

Wood pulp imports from overseas continued downward through December and for the year were 372,335 tons, distributed as follows: Sweden—224,471, Finland—132,792, Norway—14,997, Portugal—25. Imports from Canada, however, increased and by year-end were 1,678,000 tons, an increase of 64,000 tons above 1953. Total imports last year were 2,051,000, a decline of 108,000 in comparison to imports in 1953.

Exports of wood pulp were 431,000 tons, the second highest on record, exceeded only in 1940 when exports totaled 481,000 tons. Wood pulp exports last year were over two and a half times that of 1953 and had increased to the point where they exceeded imports from overseas by approximately 60,000 tons.

Pulpwood

Total receipts of pulpwood for last year reached a record high of 28,596,000 cords, an increase of 766,000 cords over receipts for 1953. Domestic receipts increased 691,000 cords, and imports were up 75,000 cords. In comparison to 1953, receipts in the Northeast region declined 202,000 cords; the Appalachian region increased 33,000 cords; the South, 38,000 cords; the Lake States region, 209,000 cords; and the Pacific Northwest 688,000 cords.

Pulpwood consumption also reached a record total 29,200,000 cords, indicative of the record wood pulp production last year. Consumption last year exceeded 1953 by 1,094,000 cords. The Northeast and Lake States regions showed moderate declines of 18,000 cords and 85,000 cords, respectively. The largest increase in consumption was in the Pacific Northwest, 744,000 cords.

Inventories at the end of December were 5,058,000 cords, a decline of 592,000 cords from the level at the end of December, 1953. Each region showed a decline ranging from 7000 cords in the Lake States to 330,000 cords in the Northeast.

Corrugated and Solid Fiber Shipping Containers

Production of container board in the fourth quarter was 0.3% above the corresponding period of 1953. Of this total, increases of 0.2% for liners and 1.4% for corrugating material more than offset a 4.4% decrease in output of container chipboard.

Liner production for the year was 4.5% below the 1953 total. Similarly, output of corrugating material and container chipboard decreased 3.0 and 14.2%, respectively, with the total output of container board down 4.5%.

Compared with the third quarter volume, liner output in the fourth quarter increased 8.9%. For the same period, corrugating material and container chipboard output increased 4.2 and 8.1%, in that order. Total container board output in the fourth quarter was 7.5% above the preceding period.

The square footage of containers shipped during the fourth quarter was 7.6% above the comparable period of 1953. In the same unit of measure, fourth quarter shipments were 6.3% above the third quarter 1954 total. For the year, box shipments, in terms of square footage of board, were 1.3% below the record 1953 volume.

In the production of containers during the fourth quarter, box plants consumed 3.4% more liners, corrugating material, and chipboard than in the fourth quarter of 1953. Also, a 3.4% increase was registered in fourth quarter board consumption as compared with preceding quarter. For the year, box plants consumed 3.4% less board than in 1953.

The improved fourth quarter volume of business resulted in a record level of operations for many firms. Order backlogs were, however, not particularly heavy as most users ordered for immediate delivery. Box inventories at the user level

The DRAPER Felt
DRAPER BROTHERS COMPANY
CANTON, MASS.

were generally low although in several areas a build-up was reported under way. Box prices were fairly stable with minor increases and decreases noted. Raw material supplies were plentiful with inventories heavier than in previous periods. Box demand continued strong into the first quarter of 1955. During January, for example, box plants consumed 8.0% more board than in the first month of 1954.

Fiber Cans and Tubes

Fiber can and tube shipments were heavier in the fourth quarter than in the third quarter of 1953. Dollar volume of fourth quarter sales was 7.6% above the preceding period. Compared with the fourth quarter of 1953, sales were down 9.7%. This decrease was due entirely to lower prices of cans and tubes as the physical volume exceeded the 1953 total by about 5%. Ammunition container requirements were below the fourth quarter 1953 volume. In contrast, for the same period can requirements for packaging uncooked biscuits increased substantially.

Fourth quarter sales of fiber cans and tubes were 9.7% below the 1953 dollar volume with cans down 23.4%. Similarly, convolute tube sales were 5.9% lower. For the same period, the dollar sales of spiral tubes and cores increased 16.9% as did miscellaneous specialties by 7.1%.

Total value of fourth quarter sales of fiber cans and tubes was 7.6% above the preceding quarter of 1954. Of this total, increases were registered in cans, spiral tubes and cores, and miscellaneous specialties; these increases amounted to 4.1, 9.7, and 15.7%, respectively. Sales of convolute tubes in the fourth quarter were 2.4% below the third quarter 1954 total.

Despite the improvement in fourth quarter business, fiber can and tube sales for the year were 15.0% below the 1953 total. In detail, can sales were off 19.9% as were spiral tubes and cores, convolute tubes and miscellaneous specialties by 3.8, 15.0, and 11.6%, in that order.

Fourth quarter purchases of cans and tubes reflected the general confidence of users as forward buying increased over previous periods.

Paper Bags

Output of bag paper in the fourth quarter was 2.5% above the fourth quarter 1953 total. For the same period, unbleached kraft bag paper production increased 2.3% whereas all other types increased 4.6%. Major gains in bag paper output occurred in December as unbleached kraft registered a 7.2% gain and all other types a 1.9% gain with the total 6.8% above the December, 1953, volume. Compared with the third quarter of 1954, unbleached kraft output increased 9.6% and all other types increased 7.6%. Total bag paper production during the fourth quarter was 9.4% above the 224,016 tons of the third quarter. For the year, bag paper output increased 5.8% in total with gains of 6.0 and 2.6% registered for unbleached kraft and for all other types of paper, in that order.

Demand for grocery, variety, and specialty bags increased in the fourth quarter over the preceding period but was generally below the fourth quarter of 1953; gains and losses, however, were relatively narrow.

Setup Paper Boxes

Production of setup boxboard during the fourth quarter was 1.8% above the final quarter of 1953. The increase in production occurred in November and December as October was below the October, 1953, total. Production for the year was 6.5% below the 1953 volume. Fourth quarter output of board was 8.4% above the 167,337 tons of the third quarter of 1954.

Seasonal demand for setup box which was apparent during middle of the third quarter increased during the final quarter with peak sales occurring in November and continuing through the first part of December. As a result of heavier seasonal requirements, fourth quarter box business increased approximately 30% over the preceding quarter. Box demand in the fourth quarter was, however, not as heavy as earlier anticipated and compared with the fourth quarter of 1953, sales were down an estimated 6%. Box sales for December were slightly above the December, 1953, total. Sales for the year were below 1953 level with the total down 7.3%.

Folding Paper Boxes

Production of folding boxboard during 1954, decreased 1.6% from the record 1953 volume. This decrease occurred in the first nine months' output, as fourth quarter volume was 2.0% above the fourth quarter 1953 total. December output of board was 5.5% above the December, 1953, total. Fourth quarter output of folding boxboard was 5.8% above the 573,976 tons of the third quarter.

For the year, dollar value of shipments was 1.3% above the 1953 total. Dollar value of orders entered during 1954, was 1.9% above the 1953 total. As measured by tonnage, orders entered and shipments billed decreased 2.3 and 2.9%, in that order, from the 1953 volume.

Paper Milk Containers

Fourth quarter output of paper milk container was approximately 15% above the fourth quarter of 1953. Compared with the third quarter of 1954, production increased about 12%. During 1954, the output of containers is estimated at 11.5% above the 1953 total.

During the fourth quarter, paperboard supplies were easier than in the preceding period. Raw material inventories were slightly below normal. Costs of paperboard were generally steady as were container prices.

Name →	*Murco Adams Clark indirect crushing*	*Nickolson rotobarker indirect crushing*	*Palmia indirect crushing*	*Sund direct crushing*	*Skoglunds direct crushing*
Manufacturer	D. J. Murray Mfg. Co., Wausau, Wis., S. D. Payzer	Nickolson Mfg. Co., 5416 –14th Ave. N. W., Seattle 7, Wash.	Fabrikor B. Palm, Palms Mek Verkstad Mobodarna, Sweden	Sund-Skovicks Verkstader, Sundsbrunk, Sweden	Dominion Bridge Co., Vancouver, B. C. Harold Swanson, Atlas Polar Co. Ltd., 54 Wolseley St., Toronto, Ont. Mr. Anders
Principle of operation	Nonrotating drum. Axle with fins which tumble the wood giving a pounding and rotating action thus removing the bark. Bark falls through mesh of drum	A series of air-powered tools which rotate around the log and scrapes off the bark	Has two carpets of chains to which knives have been welded at inclined angles. The log is laid in a trough formed by the carpets and bark is scraped off	Rotating-ring principle similar to Skoglund. Mira and Andersson. The barking unit is made up of 6 spring-loaded tools situated in the rotating ring. The log is fed through nonrotating	Uses the ring principle as does the Soderhamn, Sund and Mira. Tools operate by centrifugal force. Tools connected to ring rotate as log passes through nonrotating. The pressure of the tools is varied by varying the revolutions per minut
Cost	$16,000 f.o.b. Wausau, Wis. Mounted on skids or customer's truck	$20,000 mounted on a two-wheel trailer	....	$14,000	$9000
Weight	18,000 lb.	20,000 lb.	....	10,000 lb.	3.5 tons
Capacity and men required	3 to 8 cd./hr. 3 to 7 men. Available in 8 sizes from 48 to 110 in. in length. 3 to 15 in. in diam.	3 to 4 cd./hr. 2 to 3 men. 3 to 16 in. diam. Minimum length: 4-ft. bolts	....	2 to 12 cd./hr. 3 men minimum. 2½ to 14 in. diam. 25 to 130 f.p.m.	7 cd./hr. 4 men minumum. 30 t 80 f.p.m. Mini mum length log: 8 ft.
Hp.	26 to 60 hp.	50 hp.	2 hp.	20 hp.	25 hp.
Limiting factors	Frozen wood not completely barked	Experimental	Experimental	Knots need to be cut flush. Bolts need to be straight. Recommended minimum length bolt: 5 ft.	Knots need to be c flush. Bolts nee to be straight. Machine is large and expensive and requires well planned organiza tion

—from *Pulp and Paper Magazine of Canada*, December, 1954.

Austria

Economic recovery in Europe has been accompanied by an increased demand for wood which in Austria—a traditional wood exporting country—has finally caused a steep rise in wood prices and generally short supplies of all kind of wood on the domestic market. The paper industry is offering very high prices for pulpwood and is covering—at present—roughly one third of its annual requirement from sawlogs. The sawmill owners claim that this greatly handicaps their business, as they are not in a position to compete pricewise with this industry.

This development has now reached its climax in a serious controversy between forest owners, lumber dealers and sawmills on the one hand, and domestic wood consumers, notably the pulp and paper industry and labor interests on the other hand, with the government and its chambers trying to solve the conflict by seeking effective measures to bring the situation back to normal.

Canada

A recent partial survey by the Dominion Bureau of Statistics indicates that the production of certain packaging material (chiefly wrapping paper, bottles and jars, primary plastics, wood and fiber boxes, metal cans and caps, etc. but excluding certain boxes, tags, and labels), reached a gross value of close to $400,000,000 in 1952. The consumption of containers and packaging materials by selected consumers during that year (excluding heavy users in the dairy, meat products, and other industries) is estimated at $321,513,000.

In a group of selected Canadian industries according to the Packaging Association of Canada, the principal users of packaging material are the fruit and vegetable, brewery, bakery products, flour and feed, and distilling industries. The fruit and vegetable industry relatively and absolutely is the chief consumer of packaging material it being estimated that nearly 23 cents of every sales dollar in the industry went to pay for containers and other packaging material in 1952, resulting in an expenditure of over $48,000,000.

With the anticipated expansion in a wide range of Canadian industries (e.g., soap confectionery, pharmaceutical, paint and varnish, cosmetics, breakfast foods, etc.) it seems inevitable that the near future will see continued growth in the demand for containers and packaging and the style and standard changes involved. There will be dependence on domestic production, and in some degree on imports, for the basic materials necessary.

Cuba

Compania Technica Cubana, S. A., has received a $5,000,000 loan from the Cuban Government for the construction of a mill to manufacture bagasse pulp. The loan is for a period of 30 years at 4%, and shall take effect two years after production starts. Production must be commenced within two years of the signing of the agreement, namely by January, 1957.

ortable Barkers

Soderhamn chain flail indirect crushing	*Valo direct crushing*	*Watts direct crushing*	*WI-MAB indirect crushing*	*.... indirect crushing*	← *Name*
Soderhamn Machine Mfg. Co., Talladega, Ala.	Tyovaline OY, Kansakoulukatu 8, Helsinki, Finland	W. J. Watts, Philipsburg, Pa.	Munksunds Aktiebolag, Munksunds, Sweden	Canadian Summer Iron Works, 3550 E. Broadway, Vancouver, B. C.	Manufacturer
Flail-like set of chains beat off bark as log rotates slowly. Similar to the Carpenter	Same principle as Hooker (MIMT). Stationary head log is forced through drum to which knives are self-adjusting with counter weights and springs. 16 knives. The bark is scraped from the log and carried away by a conveyor. Log is forced through by hydraulic ram. Nonrotating	Multiple head rosser arranged in a spiral pattern which rotates and feeds the bolts against the cutterhead	Bolt is laid on 4 diagonally placed wedged-shaped belts. Mounted to these belts are a large number of sharp knives. The bolt is fed forward but retarded by a brake. The knives tear off the bark. Underbody clearance 14 in. Better results with unfrozen than frozen wood	A new debarking machine employing the principle of wire brushes. Information has been requested	Principle of operation
....	....	....	$2800	....	Cost
....	1000 lb.	....	1300 lb.	....	Weight
....	4 to 5 cd./hr. 2 to 12 in. in diam. 50 to 60 f.p.m.	....	1 cd./hr. 3 or 4 men required. 200 to 250 cu. ft./man/hr.	....	Capacity and men required
....	10 hp.	....	10 hp. air-cooled engine	....	Hp.
Experimental	Knots need to be cut flush. Wood needs to be straight for log length and small wood. Has special promise	Experimental barked bolts have a shredded condition	Sometimes barking is incomplete	....	Limiting factors

Egypt

The Council of Ministers has approved the construction of a paper mill using agricultural residues as raw material. It is understood that bagasse would be the principal fiber.

Mexico

Fabricas De Papel Tuxtepec, S. A. de C. V., is to build a newsprint mill near Tuxtepec, Oaxaca, to be in operation by the Spring of 1957. Initial capacity is to be 30,000 metric tons, but full production is not expected until 1959. The mill initially will use its own groundwood and chemical pulp is expected to be supplied by the Atenquique mill of Nacional Financiera. Later, the new plant is expected to add its own chemical pulp mill utilizing ponderosa pine.

Norway-Sweden

From the mounting frequency with which the subject is raised in the local press and trade journals, it is clear that increasing sales of wood pulp, especially chemical pulp, from the United States and Canada in European markets are causing considerable concern in local industrial circles. It is now openly acknowledged when reporting Norwegian pulp export prices that the differential between manufacturers' prices in Scandinavia and in North America is the leading factor militating against an increase in Scandinavian export prices. Exports from North America are described as anything from mere temporary supplementing of an insufficient supply from European sources to a full-scale "export offensive."

The short-term outlook for Sweden's pulp industry continues to be very favorable but there is some concern as to the possibility of American pulp being sold in greater volume in Europe below Swedish prices. Thus far the American pulp exports to Europe, estimated to total some 300,000 tons in 1954, have not perceptibly affected the European market for Swedish pulp.

Peru

W. R. Grace & Co. will spend $1,500,000 to expand by 50% the production capacity of their pulp and paper mill (using sugar can bagasse) at their Paramonga estate on the Pan American Highway, 194 kilometers north of Lima. A new machine will be placed in operation the latter part of 1955 or early in 1956, and initial production will be between 30 and 50 tons per day.

Venezuela

A new cardboard factory, with an estimated annual production of 10,000 metric tons yearly is to be built in Catia (West Caracas). Production is to start in October of this year. It is anticipated that as soon as production commences, duties on cardboard and related terms will be raised.

Switzerland

The Swiss paper mill Papierfabrik Utzenstorf in December ordered a newsprint paper machine, which represents the highest technical standard. Its construction speed will be 1830 f.p.m. and wire width 177 in.

Bagasse Newsprint

A new era in the industrial and agricultural development of Louisiana unfolded February 24 as the presses of 25 weekly and daily newspapers in the Sugar Belt rolled out regular editions on newsprint made from the by-product of the sugar cane known as "bagasse."

The newly constructed Valentine Pulp and Paper Co. mill at Lockport, La., is the first in the world to use both the pith and the fiber of the sugar cane in papermaking. Official announcement of the use of the newsprint by newspapers culminated a research and development program that was begun in the 1930's by Valentine.

In addition to newsprint, the mill is making fine writing paper, book paper, mimeograph paper, and tablet paper.

A large portion of the output of the mill is being sold to the United States Government Printing Office under the terms of a contract received at the time that production began.

Newspapers cooperating in the joint venture utilize both letterpress and offset types of printing reproduction on presses that are standard in the non-metropolitan publishing field.

The paper mill employs 180 men; 50 work in the sugar factory, 80 in the cane fields, and 35 in the Valite plant. During the regular harvest season an additional 200 persons are employed in the sugar factory. Similar developments are seen as a possibility throughout the Sugar Belt which is composed of 18 sugar-producing parishes of the state. Together they produce 700,000 tons of moisture-free bagasse, only 300,000 of which is now being used for all industrial purposes.

Sulphite Liquor Utilization

Thirteen sulphite pulp mills in Wisconsin withheld 513 million gallons of spent liquor from streams in 1954 by utilization or other nonpollutional processing. This was 8% better than 1953's 475 million gallons, Stanton W. Mead, president, points out in the annual report of Sulphite Pulp Manufacturers' Research League. Member mills continue to upgrade their liquor programs, and 1955 should see an even greater diversion of sulphite liquor away from the rivers. Most of the past year's gain in pollution abatement came in roadbinder and soil filtration processes, but experience has convinced the League and most public regulatory authorities that sulphite pollution can be overcome at an economically supportable cost only through developing big-tonnage by-products.

Averill J. Wiley, the League's technical director, makes the following statement in the annual report.

"How can fundamental research find big-tonnage uses for spent sulphite liquor?"

To answer this entirely reasonable question we must consider some solid facts.

League member mills in 1954 sold more than 250 million gallons of liquor, not including what they made into yeast. They sold it dilute or concentrated or dried; whole or desugared; some processed considerably further.

Customers bought it for just as widely varying purposes: Adhesives, to hold things together; dispersants, to keep things apart; chemical raw materials, and so on. Amazingly, they all bought pretty much the same material for all of these assorted uses.

In brief, spent sulphite liquor is a mixture of many materials and properties. Nobody knows how many, or just what, these are. Until someone finds out, liquor utilization will remain in its baby clothes.

By fundamental research the League purposes to identify, isolate, and characterize the ingredients. We need to find out what part of the liquor is sticky, what part makes materials separate, and exactly what fraction the chemical plant converts into finished product. Then the sulphite mill can save the user freight and plant capacity by shipping him the part he actually uses.

Rising birth rate and falling death rate make some authorities believe United States population will outstrip farm output by 1975.

Q. What has that to do with sulphite?

A. Something in whole liquor favorably affects soil structure, tilth, stabilization, fertility—but it takes too many gallons per acre to get results. Fundamental research can tell us what materials in the liquor impart these properties, and give a clue to practical ways to separate out this fraction.

America's high-grade ores are running out, requiring use of lean ores that need beneficiating before smelting.

Q. Where does sulphite liquor fit in?

A. Beneficiating takes dispersants, foaming agents, flocculants, binders—all of these found in liquor, but too dilute for economical use. If these valuable properties can be delivered uncluttered by useless bulk, here is a huge market. That "if" means we must learn a great deal about the fundamental chemistry of spent sulphite liquor.

No further proof is needed that sulphite liquor contains properties valuable for road surfacing; 60 million gallons were so used last year in its bulky state. Federal plans for large-scale road building create a huge market, if mills can deliver these properties compactly and at a price that will fit the opportunity.

Again, League fundamental research already has found in liquor a compound greatly needed in chemical industry. A market awaits a practical way to separate this fraction, and we are at work to find a way.

This list of opportunities could run on for pages. Nobody can know which are meaningful until fundamental research explores the fractions composing spent liquor. Then applied research can harness many of the fractions to big-tonnage tasks.

The trustees' decision to employ 50% of total budget on fundamental work is sound scientifically. Time seems certain to prove it equally sound financially.

The staff, plus scientists working on League cooperative projects, brings to this program the world's greatest accumulation of experience in studying sulphite liquor. Their experience is focused on the problem in modern laboratories specially equipped for this material. Promising fundamental findings move on to the League's extensive pilot plants that were designed for developing sulphite products and processes.

No thoughtful person who knows the facts can doubt that our nation's material resources need supplementing with the valuable properties inherent in the 3 million tons of complex organic compounds now discarded annually by the sulphite pulp mills of the United States. The League's program seeks the key to such uses.

Sulphite Research League

A top-level Swiss scientist recently joined the staff of Sulphite Pulp Manufacturers' Research League on a three months' assignment aimed at increasing United States consumption of torula yeast for human nutrition.

Peter Gfeller came to Appleton on loan from Attisholz Pulp Manufacturing Co., Solothurn, Switzerland, where he is on the technical staff. He will work until June with Sulphite League technical men on problems of improving the flavor of yeast which Wisconsin sulphite pulp mills produce as a by-product from their wood sugars.

Torula yeast was first manufactured in Europe, and much of it has been used there for human food and pharmaceuticals. Flavor has thus received longer attention from European yeast technologists than in the United States, where this product has been used principally as vitamin supplement for animal feeds.

Two Wisconsin pulp mills now operate torula yeast plants to derive this by-product from sulphite liquor formerly discarded to the streams. These are the only torula plants in North America. Any substantial increase in human consumption of the yeast would broaden the opportunity for Wisconsin sulphite mills to utilize this process and thus reduce their discharge of spent sulphite liquor to the rivers.

Pulp Chemicals Association

The growing importance of the chemicals derived from the black liquor skimmings and other by-products of the large and growing southern kraft pulp manufacturing industry was recognized recently at the annual meeting of the Tall Oil Association. A new parent association, the Pulp Chemicals Association, was formed with Albert Scharwacter, vice-president of Arizona Chemical Co., as its president and Leonard J. Doyle, vice-president of Union Bag & Paper Corp., as its vice-president. The former Tall Oil Association became the Tall Oil Division of Pulp Chemicals Association with Albert

Scharwachter as its chairman and A. E. Griffin of Camp Manufacturing as it vice-chairman.

A new Sulphate Turpentine Division was formed to handle the problems of that increasingly important Naval Store. L. A. Radeker of Champion Paper and Fibre Co. was elected its chairman and E. M. Godat of the Crossett Chemical Division of Crossett Paper Co. its vice-chairman. A third division a (Tall Oil) Fatty Acids Division was also formed.

The new association is so organized that additional divisions may readily be formed to handle the problems of any other chemicals.

The new association's headquarters will be at 122 E. 42nd St., New York, N. Y., the same address as that of the former Tall Oil Association. Dernell Every will act as secretary, T. K. Heston as assistant secretary, and I. B. Oseas as counsel for the new association and each of its divisions.

Simplified Practice Recommendations

The following are a few of the simplified practice recommendations available from the Government Printing Office, Washington 25, D. C., to assist in the selection of containers and packaging materials which are the least expensive, most easily, safely, and economically handled, and the most satisfactory unit of pack from the consumer's point of view.

Title	*Number*	*Price*
Bags, glassine	107-31	5¢
Bags, grocer's paper	42-53	10¢
Board, box; thickness of	44-36	[a]
Boxes, corrugated and solid fiber; for canned fruits and vegetables	146-52	5¢
Boxes, folding paper (for department and specialty store use)	127-41	5¢
Boxes, folding, stock, for millinery	173-54	[a]
Boxes, folding, one-pound; for coffee	64-30	5¢
Boxes, folding, stock, for garments and dry cleaning	172-54	[a]
Boxes, paper; for toiletries and cosmetics	200-43	5¢
Caps, milk-bottle; paper tubes for packaging of	218-46	5¢
Caps, paper (for) ice-cream cups	132-36	5¢
Cartons, ice cream, and ice cream brick molds	120-40	5¢
Cases, delivery; for glass and paperboard bottles	236-54	5¢
Cones and tubes (paper) for textile winding	143-39	5¢
Containers and packages for household insecticides (liquid spray type)	203-44	5¢
Containers, extracted honey	156-41	5¢
Corrugated paperboard single faced (in rolls) (for department and specialty store use)	177-41	5¢
Groceries and packaged merchandise; pallets for handling	228-47	5¢
Insecticides and fungicides, agricultural (packages)	41-42	5¢
Packages, salt	70-54	10¢
Packages, shortening, salad oil, and cooking oil	193-49	5¢
Packaging of clothes pins, spring and slotted; and sizes	188-54	[a]
Packaging of razor blades	69-27	5¢
Packaging of toothpicks; and sizes and types	189-42	[a]
Packaging of frozen fruits and vegetables	253-54	5¢
Paperboard cartons, standard sizes for hamburger buns and wiener rolls	255-54	[a]
Paper bags, for notions and millinery (for department and specialty store use)	129-41	5¢
Tags, shipping paper	93-39	5¢
Trays, food (made of waxed paper, wood pulp or wood)	187-42	[a]

[a] Available only in mimeograph form, without charge, from the Commodity Standards Division, Dept. of Commerce, Washington 25, D. C.

Hardboard Report

Available from the U. S. Tariff Commission, 8th and E Streets, N. W. Washington 25, D. C., is a report of an investigation of the domestic hardboard industry and of the import classification of hardboard.

Captive Chlorine Production

There are 15 paper mills operating chlorine plants in the United States today, with a combined capacity sufficient to supply 25% of their chlorine requirements. When Weyerhaeuser Timber Co. completes its 100 tons-per-day plant at Longview, Wash., in 1956, this figure will approach 34%. The largest captive chlorine producers in the paper industry are Champion Paper & Fibre Co., producing an estimated 92 tons per day, Brown Co., producing about 58 tons per day, and West Virginia Pulp & Paper Co., with a production of about 50.5 tons per day.

Household Papers

Disposable household paper products, now a permanent feature of the American home, are expected to reach a volume of $1,000,000 this year, and will probably continue to increase in volume over the next five years.

Paper Packaging for Rubber

In Malaya last November there was assembled on the docks a load of rubber that could have particular significance for the paper and rubber industries. As opposed to the baling methods formerly used, this rubber was packed in paper.

Special paper bag is slipped over plastic-covered rubber packet about to leave Singapore for New York—half-way 'round the world. To keep the rubber completely protected on its Malaya-to-America journey, the open end of the bag is stitch-sealed, then additionally sealed with paper adhesive tape

The rubber itself was fitted with a skin of special plastic. Over this was dropped a heavy paper bag. To form a tight closure, the open end was stitched, then sealed with paper tape.

Rubber shipped in this manner receives normal handling and is stowed both in the lower holds and in the 'tween-deck areas. Very little distortion or puncturing, and no sticking of the coverings to the rubber has been evidenced. Tests so far indicate that rubber shipped this way will arrive at its destination in better condition.

It is understood that several rubber manufacturers have an eye on the tests, and may be willing to offer a slight premium for rubber shipped in paper packets.

—from the Natural Rubber Bureau, 1631 K St., N. W., Washington, D. C.

Radiation for Pollution Abatement

Investigations at Columbia University have indicated that it may be feasible to use nuclear fission products in the treatment of pulping wastes. A practical process has not yet been devised, but preliminary work shows that nuclear radiation can destroy certain organic compounds potentially toxic to aquatic life.

Paper Mailbags

United States mail is now being shipped to Alaska in paper mailbags instead of canvas sacks. The paper sacks are non-returnable. The savings due to the substitution of paper for canvas will amount to $100,000 each year.

Tree Farms

Last year an all-time tree planting record of 811,066 acres was established, according to figures announced by the United States Department of Agriculture. Eighty-five per cent of this record planting was on privately owned land.

The Government report covering the period July 1, 1953, through June 30, 1954, showed an increase of 13% over tree plantings in the preceding year. In six years tree planting has increased 133% in the country. Private landowners of the nation last year planted 687,338 acres, an increase of 113,193 acres, or about 21%. Wood-using industries alone planted 266,510 acres of their own lands as compared to 219,798 acres in 1953. The Federal Government planted 72,980 acres, a decrease of 4632 acres from the acreage planted in 1953. State and other non-Federal Government agencies planted 50,711 acres, a decrease of 13,080.

Two states topped the 100,000-acre mark for all planting, both government and private lands. These were Florida with 106,630 acres and Georgia with 103,464. Florida also led in the area planted by forest industries, 55,454 acres. Georgia industries were second with 47,262 acres. Other states in which industry plantings were heavy include Louisiana, 43,600 acres; Mississippi, 22,091; Alabama, 15,757; Texas, 14,880; South Carolina, 13,379; Washington, 10,404; Virginia, 9318, and Arkansas, 9000. All of these states have active forest industry-sponsored Tree Farm programs.

Knowlton Brothers

A pilot-size 42-ft. fourdrinier machine that duplicates actual production conditions existing on large machines has been placed in operation by Knowlton Brothers of Watertown, N. Y.

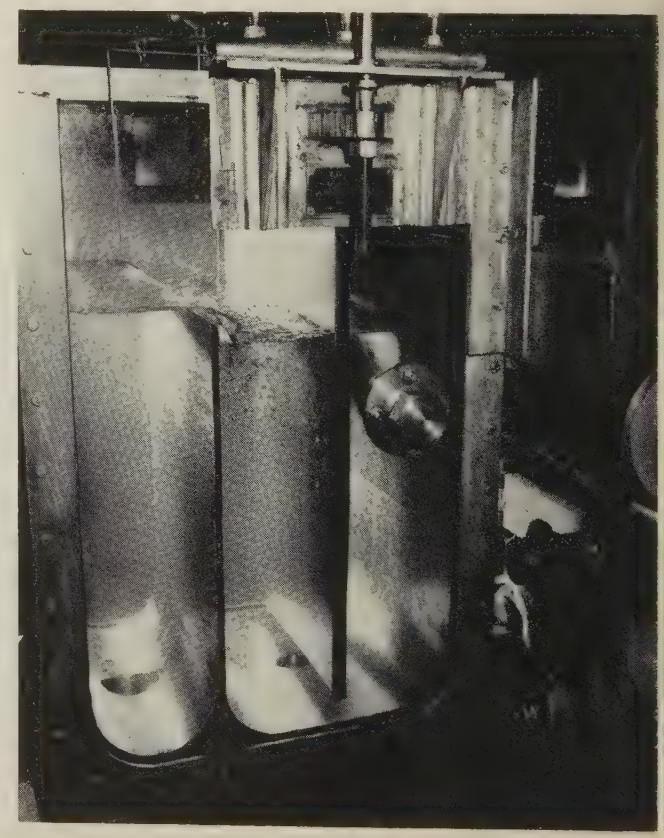
Knowlton Brothers, which has been producing paper on the same site since 1808, manufactures special technical and industrial grade papers. These include such products as filter papers, photographic wrapping and interleaving papers, saturating and impregnating papers, and other special grades. Close control is exercised over all stages of the manufacture, to insure meeting the customer's specifications.

The new machine will be used primarily for the company's own research and development program, but it also will be leased to other companies for experimental purposes.

Knowlton Brothers personnel who planned and designed the new pilot-size fourdrinier machine. From left: David C. Knowlton, president; Roland A. Hoppe, plant engineer; Robert W. McCormick, vice-president in charge of sales; Vernon C. Watters, superintendent; E. Way Clarke, production manager; Ernest L. Alton, assistant superintendent, and Horace A. Spencer, director of research

With the pilot machine it will be possible to make experimental runs with 50 to 100 lb. of fiber, with all conditions exactly the same as on a large machine.

Stock is prepared in a small-scale Jones Bertram stainless steel beater having a tub capacity of approximately 28 lb. at 5% consistency. The beater roll is 18 in. in diameter, with a 13-in. face, and weighs about 750 lb. The bedplate covers 75°



Unique glass-ended headbox on Knowlton Brothers' new fourdrinier paper machine. The second baffle (at right) is adjustable both vertically and horizontally. After adjustment it is sealed to the ends of the headbox by inflating a pair of pneumatic tubes

of the roll circumference, just as on a standard Jones Bertram beater. Especially worthy of note is the fact that the contact pressures used in regular production beaters can be duplicated in this machine, so that results obtained on the pilot machine can be correlated directly with the regular production machines. A Taylor gage indicates the pressure for the guidance of the operator.

From the beater the stock flows into a cylindrical tile stock chest with a capacity of approximately seven beaters. Then it is pumped to a Jones midget jordan which has a stainless steel filling. The mixing box and stock lines also are stainless steel, with Pyrex glass pipe inserts to allow visual observation of the flow.

The headbox is believed to be unique. It is of stainless steel, but has ends of Pyrex glass plates, so that stock flow can be studied. The second baffle is completely adjustable, both vertically and horizontally, providing variable control over flow conditions. The headbox was fabricated by Artisan Metal Products, Inc., of Waltham, Mass., to Knowlton Brothers' specifications.

The 60 by 40-mesh wire is 24 ft. 6 in. long, and 24 in. wide. The deckle can be varied within trim limits of 12 to 18 in. There are four flat suction boxes, all equipped with Synthane phenolic laminate tops. The shake is adjustable as to stroke and frequency over a wide range.

Usually the machine will run with a 14-in. Bagley & Sewall suction couch. However, this can be interchanged with a 14-in. brass solid bottom couch operating in conjunction with a rubber-covered top couch roll of the same size.

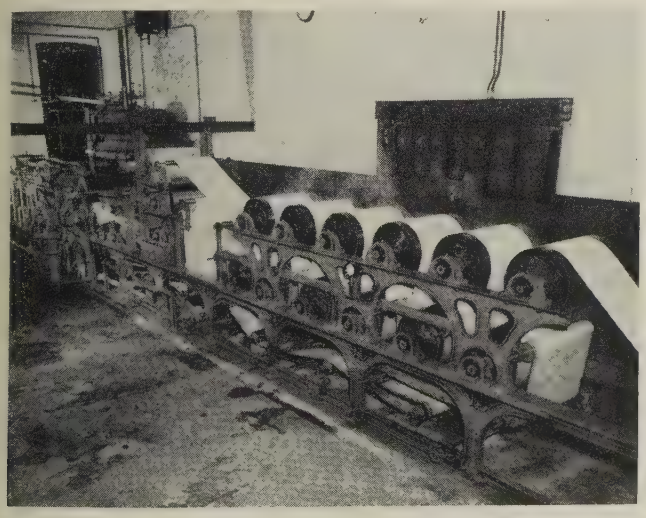
The machine has two presses of conventional design each with a 14-in. rubber-covered bottom roll, and with a brass top roll of the same diameter. The second press runs in the reverse direction, and can be used for creping.

It should be noted that couch and press rolls have been built to the same diameter as those on the Knowlton Brothers production machines, so that nip pressures correspond to those obtained on the large machines.

The drier section consists of 12 stainless steel jacketed driers, each 16 in. in diameter. They are designed to operate at steam pressures up to 50 p.s.i. An unusual roller chain and sprocket arrangement is used to drive the drier section.

Space has been left for a four-roll calender stack, which will be added in the near future, according to Mr. Knowlton. The reel is equipped with chucks which will take either 3-in. or $6^1/_2$-in. chipboard or steel-tipped cores.

The machine is driven by a 15-hp. motor driving a line shaft through an adjustable Worthington speed selector. The speed of the machine can be varied from 10 to 60 f.p.m. and the speed ratio between the units can be adjusted within a 3 to 1 range.



New pilot-size fourdrinier paper machine in Knowlton Brothers paper mill, at Watertown, N. Y. Wet end is at far left, and driers in foreground

Besides providing economical facilities for test runs as small as 50 lb., the new machine makes it possible to experiment with mechanical changes at much lower costs than would be the case in using the regular production machines. In addition the pilot machine will make it feasible to supply small runs of special grades of paper on an economical cost basis. The pilot machine was designed entirely by the Knowlton Brothers staff, and was built in their own machine shop under the direction of Roland A. Hoppe, plant engineer.

Completion of the pilot fourdrinier machine brings to more than $800,000 the expenditures that Knowlton Brothers has made in its modernization and development program in the past 10 years.

Oxford

When Oxford Paper Co. drew up its plans for a new four-stage hardwood kraft bleach plant at its Rumford, Me., mill, it took advantage of the continuity of the bleaching process and designed the plant for automatic as well as continuous operation. Beginning with start-up, in November, 1953, and continuing without interruption since that time (except for normal mill shutdown), the plant's output of high-strength, high-brightness pulp has been maintained at 150 to 300 tons per day, depending on production requirements. This is a remarkable record, especially in view of the fact that the whole plant requires the attention of but a single operator per shift. If there is a secret to this success it is neither deep nor dark: good planning and sound engineering have made possible automatic control that is at once completely centralized and yet highly flexible.

Triple Play

Although Oxford's bleach plant instrumentation was designed for a single purpose, i.e., automatic control, it is separated into three groups.

For start-up, there are four individual control consoles, one for each of the bleachery's four stages. Tel-O-Set indicators and manual loading stations mounted on the consoles permit the operator to position valves in the stock line and to control the flow of dilution water to the washers. Pushbuttons allow him to start or stop the various motors that operate the bleach plant equipment, including mixers, conveyors, pumps, and scrapers. To prevent accidental overflow and the resulting waste, an electrical interlock system links the pushbuttons in such a manner that they can be energized only in the proper sequence. Moreover, should there be a motor failure after start-up, the interlock system will automatically shut down all equipment upstream of the failure as well as sound an alarm. All controls necessary to start-up are grouped on the individual operator consoles.

After start-up, control of the bleachery is automatic and is centered at the Honeywell graphic panel which is essentially an animated flow diagram of the bleaching process. A glance at the panel and its Tel-O-Set instruments affords the operator a graphic description of conditions throughout the plant. The same instruments enable him to change process conditions to suit similar changes in laboratory tests or in the production schedule. Other Brown indicators, mounted at the appropriate symbols on the panel, continuously indicate liquid level in the high-density towers and storage chests, and the position of the important Honeywell diaphragm motor valves in the process. Layout of the panel as well as the use of color were engineered to provide flexibility of control, a quality that is essential to the operation of the new bleachery. Because of the nature of Oxford's operations, demand for hardwood kraft bleached pulp may vary between 150 and 300 tons per day. Our choice of instrumentation easily meets these requirements, even with bleached stock storage facilities to accommodate only four hours' production.

Additional instruments that fulfill no control functions whatsoever are mounted on a separate panel. Adjacent to the graphic panel, the ten conventional recorders on this panel plot continuous records of 23 important variables throughout the plant.

Instrumentation for Cost Accounting

Brown electronic integrators on seven of the recorders totalize the flow of stock, chlorine water, caustic, hypochlorite, water, and steam to the new bleach plant. These instruments furnish material flow information that leads to reliable cost accounting and points the way to real operating economies.

In and Out

The use of venturi tubes to measure the flow of brown stock and chlorine water is not unusual, although sometimes troublesome. To improve their performance, we modified one tube and replaced another. High pressure in the brown stock line to the chlorination tower sometimes results in plugging the tube. Use of a water purge at this location not only keeps the venturi tube pressure taps open at all times, but also prevents the stock from flowing back into the instrument lines. Corrosion of the venturi tube in the chlorine water line, on the other hand, prompted us to replace it with a rubber-lined orifice assembly and plastic orifice plate, used in conjunction with a Differential Converter pneumatic transmitter. This installation represents a substantial saving as compared to a corrosion-resistant venturi tube. It has been entirely satisfactory and has required no special maintenance since its installation.

Thermocouple Replaces Bulb

Stock temperature in the mixers and high-density towers has long been known to be important to the success of the bleaching process. We chose to use Brown pencil-type thermocouples to measure these temperatures rather than the usual thermometer bulbs. Because of their small mass, the thermocouples respond quickly and accurately to changes in temperature and, unlike filled thermal systems, are practically immune to errors introduced by the accumulation of stock around the bulb. Brown non-indicating electronic-pneumatic transmitters convert the electrical outputs of these thermocouples into corresponding pneumatic pressures which are then fed through panel-mounted Tel-O-Set controllers to Honeywell diaphragm motor valves in the steam lines to the mixers. Not only does the use of thermocouples improve accuracy of measurement but it also results in process control that is "on the line."

—by W. J. Stearns, J. J. Sullivan, and A. W. Welch, *Instrumentation* 7, No. 6 (1955).

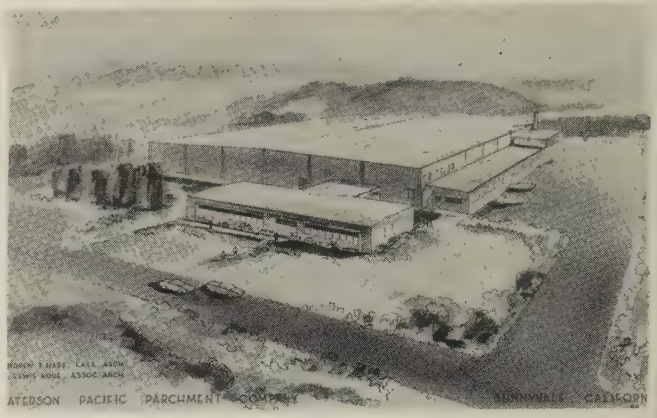
Washington Hardboard

Sale of the plant and all physical assets of the Washington Hardboard Co., of South Bend, Wash., has been made to a group of Midwesterners headed by A. C. Nasvik, president of the NU-Ply Corp. of Bemidji, Minn. NU-Ply is a board made up of a fiber core and wood veneer faces.

Paterson

Ground was broken on March 10 for a new converting and printing plant for the Paterson Pacific Parchment Co. near Sunnyvale, Santa Clara Valley, Calif. Modern in design, the new plant and air-conditioned offices will have approximately 100,000 sq. ft. of space—all on one floor. Occupancy is expected by the end of September.

The buildings, designed by Andrew T. Hass, and A. Lewis Koue, will be erected by Nicholson-Barnhart and Co. The Paterson Pacific Parchment Co. is the Western Division of the Paterson Parchment Paper Co., Bristol, Pa.



Paterson Pacific Parchment Co., Sunnyvale, Calif.

The new plant will convert and print Patapar vegetable parchment, Patax waxed paper, and a full line of Paterson specialities.

Powell River

Today noise is a very real problem, not only in industry but in our daily life. Machines run at high speeds, electric sirens and bells shriek on our highways, more and more automobiles roar or honk horns on congested streets. Noise has gone beyond the nuisance stage. It is a real and vital problem, which impinges on the comfort, welfare, and activities of our people everywhere.

The problem, from an industrial angle, is as acute in Powell River as elsewhere, and here, too, as elsewhere it is not one that is easily solved.

It is one, however, that Powell River Co., individually and collectively, has been studying for the past several years; one on which we have been working hard; and one on which we believe we are beginning to see some daylight.

The problem in Powell River has been approached from two viewpoints: (1) Studies and experiments locally and in conjunction with industry and national bodies to eliminate noise and its causes in our plant. (2) Where elimination is impossible, to provide protection measures for employees.

Today, our physicists and research staffs are working closely with the National Research Council, who, through a special committee, are concentrating on noise abatement in the pulp and paper industry. Advanced studies and experiments done in the Powell River plant have been made available to this committee. In addition, special experiments are being conducted locally by research staffs.

To speed up our studies and to consolidate information on the subject, Powell River has apppointed one of its staff as a noise abatement coordinator. He is collecting information on the problem from every available source, which will be consolidated and analyzed for management. A great deal of progress has been made and with the accelerated intensity of effort this will be speeded up.

Realizing that noise is an immediate problem and that concrete results from studies and experiments will not be available for some time, Powell River has developed progressive measures for employees: (1) soundproof booths have been installed in machine rooms. (2) The ring barker operator's station has been enclosed to cut down noise. (3) Experiments with specially designed ear muffs have been carried out in the machine rooms. Certain modifications in design, weight, and appearance are now being made, which we hope will prove beneficial.

We have not solved the noise problem in Powell River but something is being done, and the pulp and paper industry, in particular, is alert to the hazards and consequences of the noise problems, and conscious of the challenge it presents to their ingenuity and technical skill.

Powell River Co. increased its water reserve by an esti-

mated 10% last year through the use of silver iodide generators installed under the direction of I. P. Krick, Denver, Colo., the continent's leading "rainmaker."

MacMillan and Bloedel

The mills of MacMillan and Bloedel Ltd. have powerful appetites for electricity—the "juice" that turns motors of machines that convert round logs into a variety of shapes. Company mills and logging camps consume a total of 220 million kilowatts of electricity annually. That's enough to light the homes, operate the toasters, TV sets, ranges, refrigerators and run the industries of a city of 60,000 . . . the number of people to be found between Duncan and Campbell River and West to the Albernis!

Four thousand motors ranging in size from $^1/_{30}$ hp. to a giant developing 1500 hp. consume most of that huge amount of power. About half of the power consumed is generated by the company's own steam-powered plants. Remainder is bought from the B. C. Power Commission on Vancouver Island and from the B. C. Electric on the mainland.

Honors for having both largest and smallest motors go to Harmac Pulp Division. And they have the most motors, too—1180. These are production motors only. Fan and typewriter motors are not included in the list of 4000 motors.

The fully integrated newsprint mill of MacMillan and Bloedel, at Port Alberni on Vancouver Island is expected to be in operation during the last half of 1957. Production in that period is estimated at 35,000 tons. The schedule calls for 80,000 tons in 1958 and 90,000 tons in 1959.

MacMillan and Bloedel is a large pulp producer (1000 tons daily) and in 1954 the company's sales from all lines of forest products totaled $143,000,000.

The paper machine ordered for the new mill from Beloit, Wis., will be 275 in. wide, with a 260 to 262-in. trim.

The newsprint will be sold through a West Coast subsidiary, tentatively named Alberni Paper Co., of the Wright Co. of New York, N. Y., which has been distributing newsprint for 38 years and currently has contracts in 33 eastern states.

Canada Paper

Canada Paper Co., Montreal, Que., expects to start producing newsprint at its mill at Windsor Mills, Que. this month. A new newsprint machine with 180-in. trim width and estimated 130 ton daily capacity (about 40,000 tons annually) is being installed.

Anglo-Canadian

Newsprint production at the Anglo-Canadian Pulp and Paper Mills, Ltd., Quebec, Que., has almost doubled since 1928, when the daily average was only 420 tons, as against 775 tons today. In addition, the company now produces 200 tons of sulphite pulp per day, and 75 tons of paper board and boxboard.

Anglo-Canadian also has interests in two plants operating near the mill: Lignosol Chemicals Ltd., which turns the "spent liquor" resulting from the sulphite pulp process into a variety of chemical products, and the Canadian Glassine Co., a producer of waxed and greaseproof papers used principally to package food products.

The Anglo-Canadian story is particularly remarkable in that the plant has never closed since its opening, even during the depths of the depression. There were difficult days during 1933 and 1934, when the machines were slowed down and put on part-time production, but the mill kept operating. The next dip in production happened in 1941, due to war-time conditions, but demands soon began to climb, and the mill's production has steadily increased since then.

During the war years, Anglo-Canadian added a stirring chapter to its history, in setting up a shipbuilding division which numbered as many as 3300 employees at the peak of its activities. The experience and "know-how" of Anglo-Canadian mill personnel contributed greatly to the success of the shipbuilding division, which between 1942 and 1944 outfitted 14 frigates for the Royal Canadian Navy.

Anglo personnel also played a leading part in the "War-time Machine Shop Board" of the Canadian Pulp and Paper Association, an organization which between 1939 and 1945 put at the disposal of Canada's war effort the technical services and mechanical facilities of the pulp and paper industry's vast machine shops.

The Anglo-Canadian mill employs approximately 1500 people in Quebec City. In addition, some 3000 people are employed at the peak of the logging season, in woods operations based at Forestville, on the North Shore of the St. Lawrence.

National Container

A demonstration of the paper box industry in emergency operation has been completed with all records broken for quality of product, production, and delivery.

Seaboard Container, Bristol, Pa., Division of National Container Corp., supplied shipping containers for this food packaging project, said to be the largest in peacetime history. Approximately 6,000,000 containers representing 70 freight car loads or 472 motor truck loads of cartons flat—a total of thirteen and a half million square feet of paper board, were delivered by Seaboard in six weeks without interfering with normal production even though it came at a time when the normal output of the Bristol plant was at its heaviest.

The containers were used to package 57,000,000 lb. of foodstuffs in 14-lb. parcels, urgently needed and which were shipped from the people of the United States to needy and hungry families in countries of Europe, Africa, and the Near East, all this side of the Iron Curtain. Further complicating the project was the fact that the boxes were not all of one dimension but ranged in size from a carton 11 by 7 by 9 in. to one 21 by 11 by 2 in.

A total of 1800 freight car loads of food were packaged representing more than 3000 car loads when contained in the parcels ready for shipment.

In preparing the packages for shipment a total of 10,000 miles of metal banding was used and 13,200,000 ft. of gum tape.

Rome Kraft

The Winter of 1954–55 was an important one in the history of the Rome Kraft Co.; for a new production center for container board is now in operation.

The new Rome, Ga., plant is jointly owned by The Mead Corp. of Dayton, Ohio (60%), and the Inland Container Corp. of Indianapolis, Ind. (40%), which companies also own Macon Kraft Co. in Macon, Ga. Mead, the famous manufacturer of many kinds of paper, predicts that the new plant will soon more than double their available kraft supply. Inland, as well as other companies, will use the output of the plant in manufacturing corrugated shipping containers. Among Inland's products are specially designed boxes for packing all types of foodstuffs, clothing, glass containers, rubber and metal products, radios, military items, and other products vital to defense requirements.

Container board is used by the boxmaking plants for both the printed, or outside surface, and the inside surface of shipping boxes. In between these two sheets of smooth, tough paper is corrugated board made in still a third type of plant. The end product is, of course, the familiar container which holds the 24 cans of early June peas or boxes of breakfast food on the way to our grocer—"the big box" which we fill with groceries and carry home in the trunk of the car.

For the past ten years, paperboard consumption has increased at an average rate of almost half a million tons annually. And no letup in demand is in sight.

One day's (24-hr.) production at Rome Kraft, converted by Inland and other customers into boxes, would package and ship all the following items from manufacturers' plants:

128,968 21-in. television sets; 80,545 7-cu. ft. refrigerators; 361,111 cases of no. 2 cans of beans, corn, peaches, etc., and 1,875,002 boxes containing 18,757,351 individual packages of penicillin.

The plant, representing an investment in excess of $25,000,000, was begun in July, 1952, under the Government's Necessity Certificate Program of increasing the nation's productive capacity. The Rome Kraft Co. plant has seven acres of floor area inside its buildings, which are located on the Coosa River, 10 miles west of Rome.

Built in the center of rich pine country, the plant will draw its basic raw material—pulpwood—from Northwest Georgia, Alabama, and Tennessee. Thirteen hundred cords of the three major native varieties of pine—shortleaf, Virginia, and loblolly—will be processed daily.

Supplying pulpwood, major part of which is purchased from farmers and landowners, will provide employment for about 1200 people in the various wood operations. Through its subsidiary, North Georgia Timberland Co., Rome Kraft is developing in excess of 300,000 acres for pulpwood production with a staff of trained foresters. About three million pine seedlings are being planted on these lands annually in addition to the free distribution of two million seedlings to farmers throughout the area. Thus, the company is sure that it will never deplete its basic raw material.

Mead

The Mead Corp. today is producing within its own mills 90% of the wood pulp required in its board and papermaking operations. The small balance of our pulp requirements is purchased on the open market with practically all of it coming from producers in Canada and on our west coast. This change in recent years from overseas sources is due to the improved strength and quality of North American wood pulps. Sources unaffected by international disturbances also allow us to maintain better control over our inventories.

Substantial savings and better production were accomplished at the Chillicothe Division, where there is increased use of short fiber soda pulp produced in the mill recently completed. This pulp to a large extent replaced deinked paper stock and Kingsport Division soda pulp that previously was shipped to Chillicothe.

Our newly formed Central Woods Department secured pulpwood from shorter haul sources, effecting material savings in freight. At both the white paper and board mills there was a further trend toward use of dense hardwoods, principally species of oak.

With the start-up of the Rome mill, total employment in the corporation, including subsidiaries and affiliates, rose from 7200 to 7770. There were no work stoppages during the year.

Production

White paper production for the corporation for 1954 approximated 94% of capacity as compared with the white paper industry average of 91.5%. White papers produced and sold during the year amounted to 288,791 tons, a reduction of 2% from the total of 294,992 tons in 1953. Paper machines increased their average production by 16 tons per day, partially compensating for 11 fewer operating days than in the previous year.

Capital expenditures at the white paper mills were approximately $5,600,000. Emphasis was put on power facilities required by our recent expansion, to provide sufficient margin of safety against interruption in our operations, and for contemplated future growth.

The new Chillicothe machine providing increased facilities for the manufacture of high quality coated paper was in operation for its first full year.

The new warehouse at Chillicothe permitted more efficient handling of our increased merchant business and enabled the mill to effect the economies of longer runs of individual grades. Other expenditures were made in stock preparation equipment paper machine changes and finishing equipment, to add production, improve quality, and lower costs.

Kingsport's no. 3 paper machine was rebuilt and modernized to permit higher speed, better quality, and more production, thus putting us in a more competitive position.

In the mill at Escanaba, Mich., the most important of various improvements made in 1954 was a new pressure headbox installation on our no. 1 paper machine, which was completed in August. This modern facility makes it possible to step up the speed of this unit sufficiently to produce an additional ten tons per day.

One of the highlights of the year was the performance of new soda pulp mills at Chillicothe and Kingsport. Chillicothe produced 53,161 tons of pulp, compared to 40,366 tons in 1953. The mills' use of soda pulp increased 45 tons per day over the year before.

The operation of the Bristol pulp mill was suspended because of the condition of the pulp market, and is temporarily being held on a stand-by basis. The production was transferred to the more economical and efficient mill at the Kingsport Division, whose output rose from 44,813 tons in 1953 to 54,823 tons in 1954.

The pulp mills at Brunswick and Kingsport were able to produce for the market 40,074 tons of pulp in excess of our own requirements for these particular grades.

Paperboard production of the corporation and its affiliates is predominantly devoted to the corrugated shipping container field. This phase of the industry was slightly off from the 1953 peak year, producing 5,976,470 tons in 1954, or about a 3% reduction. Total linerboard volume for the industry was down approximately 4% from the previous year. The corporation tonnage of linerboard, reflecting its share of the production of the new Rome mill, was 156,732 tons in 1954 an increase of 15% over 1953.

Industrywise, corrugating material, also used in the manufacture of corrugated shipping containers, was about 1% below the 1953 level. Our own corrugating board production in 1954 was 152,102 tons, a reduction of 6% from 1953. The daily capacity of our corrugating board mills was increased by 7% due to the modernization program which was continued throughout most of our divisions during the year. Total expenditures amounted to $1,400,000 and were directed toward the strengthening of the entire production facilities. Examples of improvements are the new power center and the fourdrinier wet end on the paper machine at Sylva; the new stock inlets and new paper machine turbines at Sylva and Harriman; and major wood handling and wood preparation improvements installed at these same mills.

Also authorized but not completed during the year 1954 was a substantial expansion at the Lynchburg Division for the laminated board and specialties which are manufactured there. Existing converting equipment is being relocated and additional equipment installed. The laminated board operation during 1954 averaged slightly less tonnage produced than in the previous year because of decreased demands for these board specialties.

Affiliated Companies: Brunswick Pulp & Paper Co.—The bleached sulphate pulp mill at Brunswick, Ga., in which the corporation and Scott Paper Co. each has a 50% interest, set its eleventh consecutive annual production record. The mill operated 342 days and produced 171,356 tons of pulp at an average of 502 tons per day. This compares with a daily average of 470 tons produced in 1953, or an increase of 32 tons per day over the average for the preceding year. The quality and brightness of pulp also were improved.

Brunswick pulp is used in white paper grades manufactured at Chillicothe and Kingsport, and to some extent at Escanaba and Leominster. This pulp has improved the strength and quality of the papers made in these mills. Brunswick's small excess of pulp above our own requirements is sold on the open market.

Present timberland holdings of this company amounted to 289,963 acres at the year end, 10,673 acres having been acquired in 1954. In addition to this acreage, which is owned, the Brunswick Co. added to the acreage from which it acquires pulpwood under long-term management contracts.

Macon Kraft Co.—Macon Kraft Co., owned by the corporation (60%) and Inland Container Corp. (40%), operated 322 days in 1954 and produced a total of 223,461 tons of kraft linerboard for an average of 694 tons per day.

Macon's subsidiary timberland company in 1954 acquired 5663 acres, bringing its total holdings to 324,831 acres. When it reaches maximum yield this acreage should supply two thirds of pulpwood requirements.

Rome Kraft Co.—Rome Kraft Co., owned by the corporation (60%) and Inland Container Corp. (40%), started operations in the early part of September, 1954, and attained full production three months later, in December. In the 102 operating days total production of 44,064 tons of kraft linerboard was made for an average of 432 tons per day. Very much like the Macon mill in facilities, but even larger and more modern, the Rome mill makes kraft linerboard for shipping containers. Its operation more than doubles our capacity to make this product.

Under a certificate of necessity issued by the Defense Production Administration on Oct. 5, 1951, the company is permitted for tax purposes to write off 60% of the cost of the facilities certified over a period of five years, which will limit earnings and save taxes during that period.

Rome Kraft Co.'s subsidiary timberland companies owned a total of 329,068 acres at the year end, having acquired 31,981 acres in 1954.

St. Regis

St. Regis Paper Co. has completed an agreement to acquire through an exchange of stock, the Pollock Paper Corp., Dallas, Tex.

A new paper and a new board machine are planned for the St. Regis mill at Jacksonville, Fla. The Jacksonville mill recently set a new speed record by making prolonged runs in excess of 2000 f.p.m.

St. Regis has been experimenting with the manufacture of paper from orlon, dacron, and nylon.

North Western Pulp & Power Co., jointly owned by St. Regis and North Canadian Oils, Ltd., will begin construction of a bleached sulphate mill in Alberta, Canada, this Spring. The $33 million mill is to have a capacity of 400 tons per day, using lodgepole pine and white spruce.

Rayonier

Rayonier Inc., produced 148,134 tons of chemical cellulose during the first quarter of 1955, an all-time record for the company.

Harry A. Thurlow has been appointed temporary resident manager of Rayonier's Fernandina Beach, Fla., mill. Fred B. Doherty has been appointed general manager of Southeast cellulose manufacturing, and B. W. Haskell has been named assistant resident manager of the Jesup, Ga., mill, in charge of engineering and maintenance. H. B. Wood has been appointed resident engineer at the Fernandina Division.

Columbia

Leon Settles has been appointed plant manager of the Walloomsac Division of Columbia Box Board Mills, Inc., Chatham, N. Y. Angelo Ambrosio has been named superintendent at the Walloomsac mill.

Gair

A new and rapidly growing corrugated container plant has been added to the Gair organization by the acquisition of the properties, assets, and business of Harvey Container Corp. of Plymouth, Mich. The business will be operated as the Harvey Container division of Robert Gair Co., Inc., with the same personnel which has successfully developed the Harvey business.

Harvey Container Corp. was incorporated in Michigan in 1952, and is engaged in the manufacture and sales of corrugated shipping containers. Approximately 90% of its sales is in shipping containers, and the remaining 10% is in sheets and specialties.

The principal machinery in the Harvey plant is a 62-in. corrugator with drive and auxiliary attachments. There are also printer-slotters, tapers, stitchers, flap cutters, die presses, and other machinery and equipment necessary to fabricate shipping containers from the board produced by its corrugator.

Sweeping the boards at the 3rd annual Canadian Packaging Show, Gair Co. Canada Ltd. won six separate awards in a field of 30 prize winners. Its nearest competitor received 3 awards, 2 firms received 2 each, and 26 other Canadian packaging companies received 1 award each.

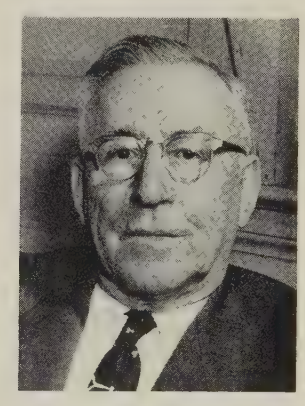
Gair has ordered its 27th Hydrapulper, a 14-ft. batch unit, to be installed in the company's North Tonawanda, N. Y., mill.

Everett

Louis Paul Fortier completed over half a century affiliation with the pulp and paper industry, the last 19 years as general superintendent of the Everett Pulp and Paper Co., a Simpson paper company, when he retired April 1 under that company's retirement program. He began his career in the paper business in 1902 with the Orono Pulp and Paper Co., Basin Mills at Orono, Me., and rose to supervisory prominence in several eastern mills. He joined Everett as superintendent on April 8, 1936.

Succeeding Mr. Fortier as general superintendent will be

Frank Hamilton, Everett Pulp & Paper Co.



L. P. Fortier, Everett Pulp & Paper Co.

Frank Hamilton who came to Everett as technical director early in 1951. For the past two years he has been assistant general superintendent in addition to his duties as technical superintendent. Prior to joining Everett, he was assistant mill superintendent of Allied Paper Mills, Kalamazoo, Mich.

Dwayne Clark, for the past several years Hamilton's assistant, becomes technical superintendent.

New York & Penn

New York & Pennsylvania Co., Inc., has doubled finishing facilities at its Lock Haven, Pa., mill. In addition, one of the papermaking machines is being widened.

At an outlay of $125,000, New York & Penn has expanded and air conditioned the finishing room at the Lock Haven mill. Floor space has been increased by 7500 sq. ft. Air-conditioning equipment, including capillary washers and conditioners made by the Air & Refrigeration Corp., have been installed to control temperature and humidity.

Relative humidity in the finishing room, where offset paper is cut, trimmed, and wrapped, will be maintained at 50 to 54% and dry bulb temperature at 72°F. Thus the moisture content of finished offset paper can be carefully controlled to meet rigid specifications. This insures a uniform product.

A new cutter and trimmer will speed finishing operations, and the company has also added a new Hayssen automatic wrapping machine. In addition, there are two Lynch wrappers. Finished trimmed sheets of offset paper are waterproof-wrapped and put on skids for shipment.

The wire of the no. 5 papermaking machine at the Lock Haven mill is being widened to 116 in. This will enable the machine to produce two wider rolls of paper after wet trimming. Thus wider sheets of finished paper can be made to accommodate the new larger offset presses.

Union Bag

The year 1954 saw the completion of a three-year expansion program at the Savannah plant of Union Bag & Paper Corp. which brought its rated capacity of finished product to a total of 1800 tons daily. Although most of the equipment had been installed by the end of 1953 and some of the additional production realized, the full program was not completed until 1954. While these expenditures contributed substantially to our improved earnings in terms of lower costs, the market did not provide sufficient demand to enable us to realize the full benefits by utilizing the maximum capacity that these expenditures provided.

In the field of by-products, the board of directors approved funds for the construction of a distillation plant to provide additional capacity for the refining of tall oil as well as improved quality and market value of our various tall oil derivatives. The products of this installation will enable the company to enter markets in which it heretofore has not been able to compete.

In addition, a new dual-purpose building, having an area of 368,000 sq. ft., was completed during the year. This structure, which will be devoted both to manufacturing and to warehousing, not only adds to the capacity of our converting operations but also contributes to efficiency and lower cost.

Further in the interests of both increased capacity and improved efficiency, the directors of the company have approved a major equipment replacement program at the Savannah mill over the next five or six years, calling for the expenditure of over $18,000,000. Large items of equipment which have been in service for 15 to 20 years will be replaced by new and more efficient units. Substantial savings will be realized from the installation of this modern equipment and, in addition, we will increase our capacity to manufacture paper and paperboard in anticipation of long-term future needs of our customers.

During the year 1954 the company also acquired a minority interest in The Hankins Container Co., one of the largest independent container companies in the country. A sales contract, under which we will provide a large proportion of the containerboard used by Hankins, was concluded to be effective when their current contract commitments have been fulfilled. It is felt that a close relationship between our company and one of the leading converters in the box field will work to the mutual benefit of both organizations for many years to come.

With particular emphasis on insuring the long-term future of the company, an expenditure of $1,500,000 for additional woodlands was made during 1954. This brings our total holdings to about 900,000 acres and helps to insure a perpetual raw material supply for our Savannah mill. Further in this connection, the woodlands division during the 1954–55 pine seedling planting season will supply private landowners and others with 5 million seedlings and will plant an additional 10 million seedlings on our own lands.

Also in 1954 Union Bag sold its relatively small specialty bag business, operated at Hudson Falls, N. Y., to Arkell & Smiths. Under the agreement between the two companies, Union Bag will continue to act as selling agent for the products of this plant. This sale was consummated at no loss in book value and, to our great satisfaction, the continued operation of the plant at Hudson Falls will provide continuing employment for a large percentage of the skilled employees who had worked for our company for many years and who owned homes in that location.

Union Bag's Savannah plant broke all previous records in pulp and paper production in March, 1955. The company's six big paper machines rolled out an average of 1821 tons of kraft paper and paperboard every day during the month of March. The figure topped by a wide margin the previous average daily tonnage record, set in October, 1953, of 1801 tons.

During the month of March a total of 56,464 tons of paper and board came out of the Union Bag plant, the most product ever turned out by the plant in one month since it first went into operation back in 1936.

The pulp mill's average daily production during March was 1895 tons.

Mando

Production figures for all three mills of Minnesota and Ontario Paper Co. reached an all-time high in 1954 of 291,641 tons, some 8000 tons more than in 1953.

The company now has eight paper machines—three at International Falls, Minn., three at Fort Frances, Ont., and two at Kenora, Ont. A ninth machine is planned to be installed at Kenora.

The International Falls specialty mill has a paper coating machine designed by company personnel. This equipment lays an unusually even coating on various types of paper resulting in higher grade products for special uses. The International Falls mill also has supercalendering equipment to provide a highly smooth printing surface.

International Falls is the site of the company's most diversified mill. Here 250 tons of specialty papers are made daily. It is equipped to make a wide variety of both chemical and groundwood paper products.

There are a sulphite mill, a kraft mill, and three bleach plants. At Fort Frances groundwood specialty paper and newsprint are made, while Kenora's facilities are devoted to the manufacture of newsprint.

Mando's Insulite division has four machines that can produce about 1.3 million square feet of board a day. Operating on a seven-day schedule, these machines produced 465.9 million square feet of board last year. This represents a new production record, some 10 million square feet more than 1953's record output.

All told, the Insulite line includes more than 20 products, including sheathing, coated interior wallboards, acoustical ceiling tile, roof deck, roof insulation, and other industrial boards.

The present Insulite plant is to be extended by 85,000 sq. ft. of floor space. The result will be a streamlined operation, as fabricating facilities will be moved from the fifth floor of the present mill to the new first floor area allowing the use of straight-line production techniques and the use of overhead and other types of conveyors. New manufacturing equipment will also be installed in a move toward the production of higher density products.

Orchard

The Orchard Paper Co., St. Louis, Mo., announced recently its purchase of the Racquette River Paper Co., Potsdam, N. Y., one of the largest integrated pulp and paper mills in northern New York. The Racquette River Paper Co. will become a wholly owned subsidiary of the Orchard Paper Co. and will operate under the name, Racquette River Paper Corp.

Orchard Paper Co. manufactures over 150 different paper products including decorated wrapping papers and bags, box coverings, coated papers, laminated paper, wax papers, and a large variety of industrial paper products. Orchard is the largest manufacturer of store use Christmas and gift papers, marketing their product under the trade name, "Beauty Matched."

Orchard pioneered the manufacture of VPI paper, a rust-preventive coated paper which is being used in increasingly larger amounts each year. Orchard also pioneered the idea of a sales training school for paper merchants and is one of the first rotogravure and aniline printers in the United States.

According to R. H. Orchard, president, the Racquette River line will be greatly expanded in the immediate future. Three large new catalogs of printed and embossed wrapping papers and bags are scheduled for immediate release.

As far as the future is concerned, Orchard stated that plans are being made to increase capacity at the Potsdam mill as far as possible. Over $1,000,000 will be spent on a new plant layout, a new research and quality control laboratory, the addition of printing and bag manufacturing equipment, as well as improvements in the pulp and paper mill to effect a certain economy while increasing production.

The sales forces of Orchard and Racquette River will be consolidated so that both groups will be selling the products of both plants. The manufacture of certain products will be shifted to Potsdam to effect a freight savings for Eastern customers.

The Racquette River Paper Corp. now employs over 400 men and women in the pulp and paper mill and converting plant, as well as a forestry staff to manage their 50,000 acres of timberland.

Crossett

Nowhere has the search for better conservation and utilization practices been greater than at Crossett, Ark. And part of this search recently opened up the equivalent of thousands of acres of forest land without adding a single tree to the timber that surrounds the Crossett mills. The method is one of better utilization—a method that will provide the equivalent of 15,000 cords of wood for papermaking each year.

This is the story:

For years sawdust, slabs and edgings—the latter two are names for pieces of wood trimmed from lumber during the manufacturing process—have gone into the furnaces to aid in the manufacture of electricity. Now this fuel is essentially the same material that the paper mills are turning into paper. As pulpwood it had a higher value than the natural gas it was replacing.

However, there were certain elements that made it impractical to use as pulpwood. The sawdust either cooked away in the papermaking process or resulted in a weak pulp. The slabs and edgings couldn't be used because the bark of the tree remained on them and bark cannot be used in making paper because it leaves dirt specks.

The sawdust problem was written off—at least at the present—as being impractical but if the edgings and slabs were trimmed of bark, they could be chipped up and used for papermaking.

Investigations proved that the bark could be more easily removed from the pine sawlogs before they were cut into rough lumber. Crossett was faced with the problem of finding a barker that would remove all the bark from the logs and still work fast enough to keep the mills running.

When Crossett began the investigations the only mills barking logs were a few large sawmills on the West Coast and one large mill in the East. Most of these mills were using high pressure streams of water to knock the bark from the logs.

There were other barkers being made, however, that did not utilize water. The Nicholson Roto Barker seemed to be the answer to Crossett's problem, and the second barker made of this new design was purchased and installed at the Crossett sawmills.

The logs are fed lengthwise through the barker by log haul chains and heavy rolls are used to hold the logs in position. The barker itself is a big ring with four large scraping tools which revolve with the ring and around the logs. These tools are controlled by air pressure; and when the bark sticks tightly, more pressure is added so that the tools can efficiently scrape the bark from the log. The arms which hold the tools are hinged inside the ring to allow the tools to be extended or withdrawn. This enables the barker to bark logs from 8 to 30 in. in diameter. In one day this barker has debarked as many as 2600 logs.

The bark is not wasted but is carried to the furnaces where it is burned in the manufacture of steam. Next the pine logs, now bare of bark, are carried into the mills where they are sawn as usual. But instead of the slabs and edgings being carried to the hog, where formerly they were cut into smaller size, they are carried to a chipper where they are cut into chips suitable for papermaking. Since the slabs and edgings at the sawmills were too light to be chipped in the standard paper mill chipper a forced feed chipper was installed at the sawmills.

Now as the chips leave the chipper they are piped into special railway cars for transportation to the paper mills.

That is the story. Pine that once had only fuel value is now being turned into paper—but, really, this is only part of the story. The search to save continues and perhaps some day hardwood may go through a similar process or perhaps the search will find an economical method for using sawdust.

Idaho College of Forestry

The College of Forestry of the University of Idaho has published a list of publications on Forest Management and Utilization, Range Management, and Wildlife and Fisheries Management, available without charge from the Forest, Wildlife and Range Experiment Station, Moscow, Idaho.

Brooklyn Poly

The Polytechnic Institute of Brooklyn will hold the 12th annual series of Summer Laboratory Courses from June 6 to June 17, 1955. Courses will be offered in polymerization and copolymerization techniques, properties of macromolecules in solution, and industrial applications of x-ray diffraction. Inquires should be addressed to Mrs. Doris Cattell, Summer Laboratory Courses, Polytechnic Institute of Brooklyn, 99 Livingstone St., Brooklyn 1, N. Y.

Lowell Tech

The paper engineering department at Lowell Technological Institute will hold a Summer course in "Paper—Its Properties and Uses," June 20 through July 1 at the Institute in Lowell, Mass.

Instructors will be Prof. John Lewis, B.S., M.S., head of the department, Prof. Norwood H. Keeney, B.S., M.S., and several guest lecturers to be announced. No prerequisites are required. The courses are open to men and women who are high school graduates. In the past, this Summer course has attracted men from the paper industry and college graduates seeking a refresher course.

The program is divided into two group activities after a common first week. The division is on a basis of interest in "fine" or "coarse" papers.

Four students in the paper engineering department at Lowell have been awarded scholarships of $100 each from the Geoffrey Broughton scholarship fund, established by 12 different paper companies in honor of the first head of the paper department at L.T.I.

They are Fred Iannazzi of Lawrence, class of '55; Robert Crowe of Lowell, '56; Frank Major of Lowell, '57, and Robert Wellspeak of Lee, '58.

The Geoffrey Broughton scholarships were given by 12 different paper companies in honor of the first paper department head of L.T.I. Left to right are shown: Robert Wellspeak of Lee '58; Frank Major of Lowell '57; Prof. Lewis; and Fred Iannazzi of Lawrence '55. Robert Crowe of Lowell, '56, was absent when the picture was taken

Contributing paper companies include American Writing Paper Corp., Holyoke; Carter, Rice and Co., Boston; Champion-International Co., Lawrence; Crocker, Burbank and Co., Assn., Fitchburg; Chemical Paper Manufacturing Co., Holyoke; Fitchburg Paper Co., Fitchburg; Robert Gair Co., Inc., New York; McLaurin-Jones Co., Brookfield; Nashua Corp., Nashua, N. H.; Strathmore Paper Co., West Springfield; Tileston and Hollingsworth Co., Boston; Byron Weston Co., Dalton.

Western Michigan

Bert H. Cooper, vice-president of the Kalamazoo Paper Co., has been re-elected chairman of the advisory committee on paper technology at Western Michigan College.

C. M. Sisson, president and general manager, Mac Sim Bar Paper Co., Otsego, is the new vice-chairman, and A. H. Nadelman, head of the paper technology department at Western, continues as secretary.

Newly added to the committee are J. J. Harrison, technical director and general superintendent, Michigan Carton Co., Battle Creek, and Dwight L. Stocker, president, Kalamazoo Vegetable Parchment Co.

Also serving on the college-industry advisory committee are A. A. Christian, assistant secretary and mill manager, Lee Paper Co., Vicksburg; F. C. Fischer, vice-president and secretary-treasurer, Allied Paper Mills, Kalamazoo; D. H. Greene, chairman of the board, Otsego Falls Paper Mills, Otsego, and E. E. Ludwig, vice-president, Bermingham and Prosser Co., Kalamazoo.

Representing the college, in addition to Mr. Nadelman, are: Wynand Wichers, vice-president; George E. Kohrman, director of vocational and practical arts education, and Gerald Osborn, head of the chemistry department.

Certificates of appreciation have been awarded by the advisory committee to the two outgoing members of the committee; Martin J. Galbraith, technical director, Sutherland Paper Co., Kalamazoo, and J. C. Wood, vice-president, Kalamazoo Vegetable Parchment Co.

Syracuse

Studies have shown that chemical debarking is a useful tool, not only of practical value in planning and executing logging schedules, but also in silvicultural treatment of the forest.

Representatives of seventeen sponsoring pulp and paper and chemical companies reviewed the results of a project on chemical barking for which $175,000 was granted.

The broad systematic study of the problem was undertaken to learn more about factors influencing chemical barking, to determine the movement and distribution of the chemical in the tree, and to ascertain its effect on the living tissues. Intensive work on the College's Huntington Forest, combined with that of the cooperating sponsors on company lands at ten locations in New England, New York, and Pennsylvania has proved the practicability of applying a toxic chemical to the living tree during the sap-peeling season.

Among the sponsoring companies were the American Smelting and Refining Co., South Plainfield, N. J.; the Eastern Corp., Bangor, Me.; Eastern Pulpwood Co., Calais, Me.; Fraser Companies, Ltd., Edmundston, N. B.; Glatfelter Pulp Wood Co., Spring Grove, Pa.; Hollingsworth & Whitney Co., Boston, Mass.; International Paper Co., New York, N. Y.; Oxford Paper Co., Rumford, Me.; Penobscot Chemical Fibre Co., Great Works, Me.; St. Lawrence Corp., Ltd., Montreal, Can.; St. Regis Paper Co., Deferiet, N. Y.; West Virginia Pulp & Paper Co., Georgetown, S. C.; Armstrong Forest Co., Johnsonburg, Pa.; Brown Co., Berlin, N. H.; Dead River Co., Bangor, Me.; Marathon Corp., Rothschild, Wis.; and the Pulp and Paper Research Institute of Canada, Montreal.

Ipex

The International Printing Machinery Exhibition will be held at Olympia, London, England, July 5–16, 1955. Since the exhibits will be in operation, Olympia will become the largest printing works in the world in July.

National Chemical Exposition

The 9th National Chemical Exposition will be held in Cleveland, Ohio, Nov. 27–30, 1956.

Welding Show

The National Spring Meeting and Welding Show of the American Welding Society will be held at Kansas City, Mo., June 7–10, 1955.

Exposition of Chemical Industries

The 25th Exposition of Chemical Industries will be held at the Commercial Museum and Convention Hall, Philadelphia, Pa., Dec. 5 to 9, 1955.

Crucible

Crucible Steel Co., Pittsburgh, Pa., has been granted patents covering ranges of chemical composition expected to result in three or more new steels.

Reliance

Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, Ohio, has issued a new bulletin (No. C-2002) describing the new Reliance Super "T" Line d.c. motors with dynamic response.

Freeport Sulphur

Freeport Sulphur Co. has begun production of sulphur at a new mine, Chacahoula, near Thibodaux, 50 miles west of New Orleans, La. Set in the midst of a 100,000 acre cypress swamp, the new facilities include a power plant to supply superheated water, compressed air and electric power for the Frasch mining process, an office, machine shop, warehouse relay station, cooling plant, and storage and loading facilities.

Hooker

The consolidation of Hooker Electrochemical Co. and Durez Plastics & Chemicals, Inc., was approved recently. Durez will be continued as the Durez Plastics Division of Hooker.

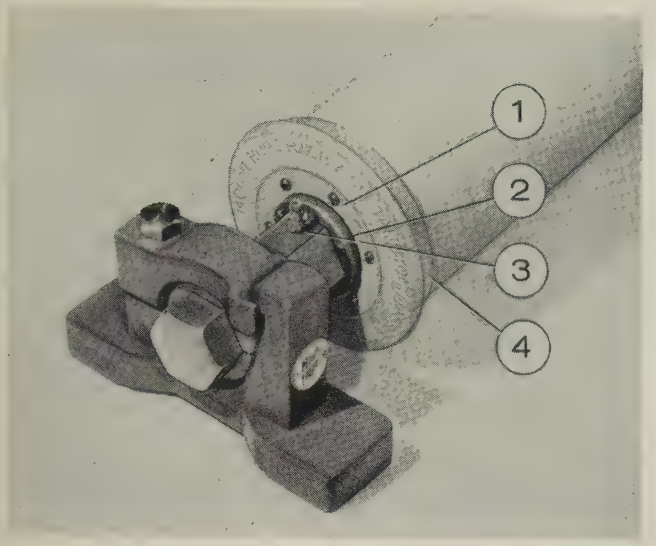


Photo shows Mount Hope Machinery Co.'s newly designed end seal for 4¼ and 6-in. diameter expanders used in manufacturing textiles, plastic sheets, and paper. Especially designed to waterproof the bearing area, the new end seal (1) is precision molded in one piece to provide a close but non-contacting fit (2) around expander axle. Grease, injected through a cadmium-plated Alemite fitting (3), serves as an effective sealant. Only one fitting is provided at each end and it is located on the stationary axle so expander may be lubricated while in use. A water flinger (4) that throws off most moisture before it reaches bearing area is included as part of the seal design

MOORE & WHITE

The Moore & White Co. has moved its headquarters into a modern new office building at 300 East Hunting Park Ave., Philadelphia, Pa.

PERMUTIT

Sheller L. Steinwender has been appointed vice-president of the Permutit Co., New York, N. Y.

Permutit has issued a bulletin (No. 2386-A) on the company's zeolite water softeners.

J-M

Edward D. Flavin has been appointed vice-president of the Johns-Manville Sales Corp., and manager of Special Industries, Industrial Products Division, succeeding L. A. Baldwin who has retired after a 35-year career with the company.

CURLATOR

Bert Lajoie has been appointed Canadian sales representative of the Paper Division of the Curlator Corp., East Rochester, N. Y.

MONSANTO

Monsanto Chemical Co.'s Plastics Division, Dept. SX, Springfield, Mass., has issued a bulletin describing the company's new modified styrene polymers which are soluble in water but insoluble in almost all organic solvents.

RESEARCH-COTTRELL

Charles E. Beaver has been elected a vice-president of Research-Cottrell, Inc., and S. E. Specht has been appointed assistant sales manager.

J. O. Ross

J. O. Ross Engineering Corp., 444 Madison Ave., New York, N. Y., has published two new bulletins: no. 25, Ross Air Systems for the Pulp & Paper Industry, and no. 34, Ross Air Systems—Supplementary Equipment.

CYANAMID

The following new appointments have been made within the paper chemicals dept. of American Cyanamid Co.'s Industrial Chemicals Division: Alvin R. Sinclair is assistant director of the Paper Chemicals Application Laboratory in Chicago; J. L. Davis will cover the western Wisconsin and Minnesota sales territory; R. W. Harding will handle sales in eastern New York; M. F. Healy will cover eastern Wisconsin and upper Michigan, and J. F. Hillman is assigned to Illinois, Indiana, Iowa, Missouri, Kansas, and Colorado.

FOXBORO

The Foxboro Co., Foxboro, Mass., has published a bulletin (5A-13) describing the company's new Model 41A Pneumatic Indicating Controller.

LAWRENCE PUMPS

Lawrence Pumps Inc., Lawrence, Mass., has issued a new bulletin (210-2) describing the company's line of self-priming pumps.

BECCO

The Becco Chemical Division, Food Machinery and Chemical Corp., Buffalo, N. Y., has published a new bulletin (No. 64) discussing the use of peroxide as a final-stage treatment in bleaching kraft and soda pulp.

AMERICAN RESINOUS CHEMICALS

American Resinous Chemicals Corp., Peabody, Mass., is offering Arcco C 607, a new heat seal solution coating for use on glassine, aluminum foil, or coated papers.

STALEY

Robert L. Schuerman has been appointed assistant manager of industrial sales in charge of sales to the paper and corrugating industries for A. E. Staley Co., Decatur, Ill. James W. Hurley has been named manager of market research for the industrial sales dept.

BLACK-CLAWSON

Ronald G. Goodwin has been appointed sales manager of the new Pandia Inc. division of Black-Clawson Co., 250 Park Ave., New York, N. Y. Mr. Goodwin is in Japan for the start-up of the Pandia continuous digester system at Kanzaki Seisha K. K., Chuo-ku, Tokyo.

Louis F. Cross, Jr., has been named assistant to the sales manager of Pandia, J. B. Scott has been appointed chief engineer, and J. M. DeCew has joined the Pandia sales staff.

Pandia equipment is to be used for the pulp mill system of National Gypsum Co.'s new mill at Mobile, Ala. The new insulation board mill will have a three-tube Pandia continuous digester.

R. L. Schuerman, A. E. Staley Mfg. Co.

R. G. Goodwin, The Black-Clawson Co.

J. M. DeCew, The Black-Clawson Co.

J. E. Dain, The Black-Clawson Co.

John E. (Jack) Dain has joined the sales staff of the B-C's Dilts Machine Works Division at Fulton, N. Y., in connection with the company's winder-slitter development program.

B-C's Shartle Bros. Machine division has contracted to supply eight model 24-P Selectrifier screens to the Kvarnsveden mill of Stora Kopparberg Bergslags A.B. at Falun, Sweden.

Pyroxylin Products

Eastern manufacturing activities of Pyroxylin Products, Paoli, Pa., have been separated from the present company and organized as Pyroxylin Products Co. of Pennsylvania, Inc.

Bristol

The Bristol Co., Waterbury, Conn., has issued a new bulletin (Q 1304) on instrumentation for pH measurement and control.

Bristol is offering vapor-pressure actuated thermometer systems which record on uniform charts.

A new Bristol bulletin describes the company's line of water level gages for indicating recording, controlling, and telemetering.

Bulkley, Dunton

Bulkley, Dunton Processes, Inc., has appointed H. E. Danby Co., Indianapolis, Ind., Nicholas A. D'Arcy, Jr., Huntington Park, Calif., W. H. Davidson Co., Wayne, Pa., and John D. Homan, Tampa, Fla., as sales agents and representatives.

Honeywell

Minneapolis-Honeywell Regulator Co., Wayne and Windrim Ave., Philadelphia, Pa., has published a new issue (Catalog 5002) of its composite catalog of Honeywell industrial instruments and equipment.

Ingersoll-Rand

Ingersoll-Rand, 11 Broadway, New York 4, N. Y., has issued a new Motorpump Bulletin, Form 7093-E, covering their entire line of close-compiled motor pumps from 1/4 to 75 hp. for delivery of 5 to 2800 g.p.m.

Another new I-R bulletin, Form 10,040, describes the company's type "5" and "55" heavy duty diesel engines in sizes from 375 to 1000 hp.

Westwill

Westwill Co., Westport, Conn., is supplying rust inhibitor paper to Schick Co., for protection of a 50-ton inventory of electric shaver parts which has been accumulated in connection with the removal of the Schick plant from Stamford, Conn., to Lancaster, Pa.

Downington

As part of its 75th anniversary celebration, Downingtown Mfg. Co., Downingtown, Pa., held open house for a week recently. Founded in 1880, Downingtown has expanded from an original 2500 to 99,500 sq. ft. of floor area at Downingtown, Pa., plus facilities of its new subsidiary, Monarch Forge & Machine Works, Portland, Ore.

Cleaver-Brooks

Cleaver-Brooks Co., Milwaukee 12, Wis., has issued a new tabloid (bulletin AD-144) presenting the CB models of self-contained boilers.

C-B has appointed the Delval Equipment Corp., 4610 N. 15th St., Philadelphia, Pa., as manufacturer's representative.

Dowell

Dowell Inc., P.O. Box 536, Tulsa 1, Okla., has issued a new bulletin on chemical cleaning.

Belding

Belding Corticelli Industries, Inc., new subsidiary of Belding Heminway Co., New York, N. Y., has been licensed by du Pont to produce and market Nylon 8, a new plastic with greatly increased life-prolonging qualities for industrial and consumer products.

Combustion Engineering

Combustion Engineering Inc., New York, N. Y., has started a long-term expansion program of which a major part will be facilities for the manufacture of nuclear power. An initial appropriation of $7 million has been approved.

Dorr-Oliver

Dorr-Oliver Inc., Stamford, Conn., has issued a bulletin (No. 310) describing the Oliver Type L Centrifugal corrosion resistant chemical pump.

Dorr-Oliver has opened a new office in the Midland Bldg. in Cleveland, Ohio, and has relocated its Chicago office in Merchandise Mart.

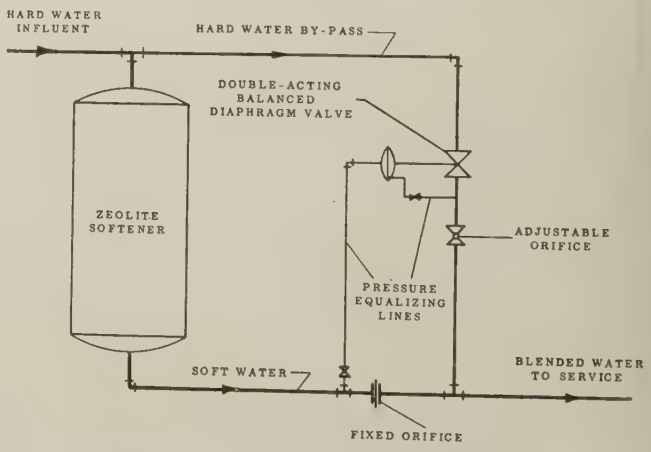
Norton

The Los Angeles district office of Norton Co. has moved to 5905 Pacific Blvd., Huntington Park, Calif.

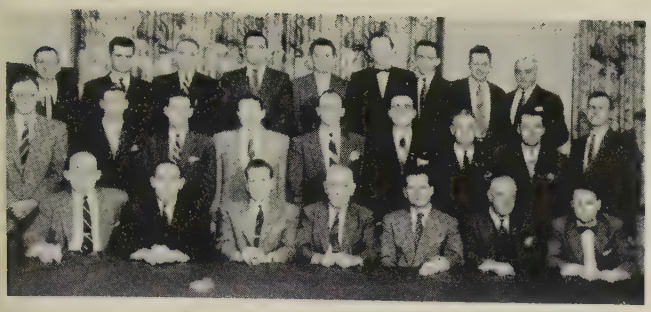
Graver

Graver Water Conditioning Co., 216 W. 14th St., New York, N. Y., offers a zeolite bypass system for treating water to a controlled degree of hardness.

Graver bulletin WC-117 discusses industrial and municipal waste treatment equipment.



Graver hard water bypass system



National Adhesives (Canada) Ltd. and National Starch Products Inc. (U. S.) executive and sales representatives held joint meeting in Toronto. Reading left to right, back row: J. A. LaRose, Marc Archambault; W. A. Sharpe, Arthur Bourke, Edward Orzech, R. W. Harvey, M. J. Stasko, A. J. Best, Gordon Bennett. Middle row: Kjell Talgoy, Peter Lake, Charles Westover, G. L. Trubin, G. W. Burgoyne, G. F. Wright, L. R. Binmore, A. R. Meredith, William Sederlund. Seated: Donald Staunton, Robert Bintz, Norman Riley, Ernest Hofmann, Donald Pascal, A. B. Meredith, B. V. Schaub

National Adhesives (Canada)

Executive and sales representatives for National Adhesive (Canada) Ltd., and National Starch Products Inc. (U. S.) recently held a joint meeting in Toronto to exchange ideas and sales techniques and to discuss new products, types of applications, and new adhesive outlets.

Philadelphia Quartz

Philadelphia Quartz Co., Public Ledger Bldg., Philadelphia, Pa., has issued a folder on the treating of concrete with silicate.

G.E.

The General Electric Co., Schenectady, N. Y., has issued a new catalog GEC-1026, giving buying information on a.c. motors, and GEC-1260A giving information on general purpose control devices.

National Container Corp., Valdosta, Ga., has installed a new G.E. drive on a regenerative tension paper rewinder designed to rewind 30 to 90-lb. sheets at speeds up to 5000 f.p.m.

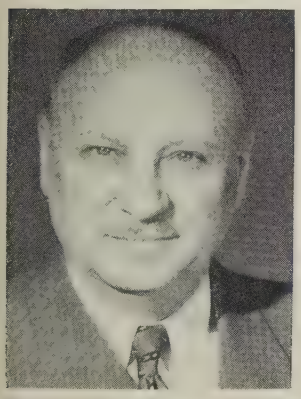
Nopco

The Nopco Chemical Co., Harrison, N. J., has acquired new warehouse and office facilities in Portland, Ore., and is now represented in the Northwest by John J. Ryan.

Ralph Wechsler has been elected president of Nopco, succeeding Thomas A. Printon, who will continue as chairman of the board.

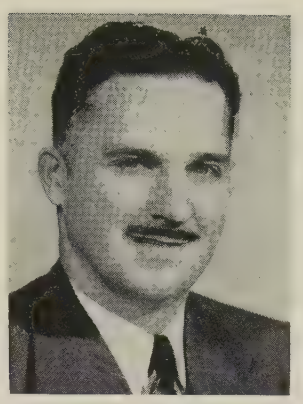
Inglis

C. B. Davies has been appointed manager of the paper machinery division of the John Inglis Co., Toronto, Canada.

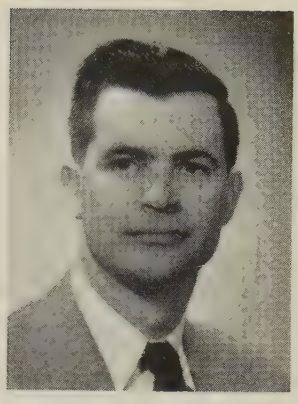


Ralph Wechsler, Nopco Chemical Co.

C. B. Davies, John Inglis Co.



P. F. Neumann, Hercules Powder Co.



G. E. Sanford, Improved Machinery Co.

Hercules

Hercules Powder Co., Wilmington, Del., has issued a pamphlet describing its $2^1/_2$-lb. brick defoamer, designated Defoamer 4.

P. F. Newmann has been appointed manager of Hercules rosin size sales, T. S. Morse becomes manager of paper chemicals sales service, J. K. Farrell is now manager of paper chemicals product development, and R. R. Buss is acting manager of the Wilmington branch sales office.

Impco

Guy E. Sanford has been appointed sales engineering representative in the South for Improved Machinery Co., Nashua, N. H.

SKF

SKF Industries, Inc., has acquired a controlling interest in Tyson Bearing Corp., Massillon, Ohio.

Rhodia

Rhodia, Inc., New York, N. Y., has added "Alamask P 6D" to its line of reodorants for alkaline pulping. Another new product "Alamask D," is used for masking traces of mercaptan odors in neoprene or similar synthetic rubber used in bag stocks, coatings, or as latices.

Stowe-Woodward

Research, manufacturing, and sales personnel of Stowe-Woodward, Inc., held their annual sales engineering conference recently in Newton, Mass. The subject of the meeting was the improvement of roll performance through careful selection of the proper rubber coverings to match operating conditions.

Seated left to right: Roy Tewksbury, F. P. Thornton, Jr., A. F. Fisk, H. H. Jensenius, C. A. Nichols, J. D. Retallick, Mark LaRue, R. P. Arnold, W. B. West. Standing left to right: O. P. Arnold, C. B. Blanchard, D. G. McRitchie Jr., L. A. Cole Jr., C. J. Ferrara, E. S. Greene, Clarence Morganstern, C. M. Schermerhorn, W. E. Greene, J. T. Gordon, J. D. Dickson, Jr., L. E. Schillo, J. H. Glander, F. G. Hadley

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Acid Pulping Committee

The personnel of the Acid Pulping Committee is now as follows:

N. S. Lea, *Chairman,* Scott Paper Co., West Coast Division, Everett, Wash.
E. H. Woodruff, Rayonier, Inc., Port Angeles, Wash.
K. G. Booth, Crown Zellerbach Corp., Camas, Wash.
E. O. Ericsson, Puget Sound Pulp and Timber Co., Bellingham, Wash.
P. J. Frost, Oregon Pulp and Paper Co., Salem, Ore.
F. J. Weleber, Publishers' Paper Co., Oregon City, Ore.

Lake States Subcommittee:

R. L. Davis, Detroit Sulfite Pulp and Paper Company, Detroit, Mich.
N. L. Malcove, Northern Paper Mills, Green Bay, Wis.
J. N. McGovern, Parsons & Whittemore Inc., New York, N. Y.

Eastern Subcommittee:

F. J. McCourt, International Paper Co., Palmer, N. Y.
O. E. Anderson, International Paper Co., Chisholm, Me.
J. G. L. Caulfield, Eastern Corp., Bangor, Me.
T. Gerace, St. Regis Paper Co., Deferiet, N. Y.
W. H. Kraske, Oxford Paper Co., Rumford, Me.
J. D. Miller, International Paper Co., York Haven, Pa.

The Acid Pulping Committee held its annual meeting in New York in the grand ballroom of the Commodore Hotel on Feb. 12, 1955 at 2:00 p.m.

Committee members present were E. O. Ericsson, Puget Sound Pulp and Timber Co., Thomas Gerace, St. Regis Paper Co., J. D. Miller, International Paper Co. and N. S. Lea, Scott Paper Co., Chairman. Others present were R. I. Thieme, Scott Paper Co., John McEwen, Weyerhaeuser Timber Co., R. J. Stevens, Canadian International Paper Co., and W. D. Kerr, the Pulp and Paper Research Institute of Canada.

TAPPI-sponsored research projects were discussed, current projects were reviewed, and possible new ones were discussed.

1. Project Number 47. The project deals with equilibrium work on NH_3-SO_2-H_2O using a radioactive counting technique and was initiated on June 20, 1951 by a grant of $2000 to the University of Washington and was followed by an additional $2000 grant in November, 1952. Mr. Hayden did this work which is now complete and ready for publication.

2. Project Number 66. This project deals with equilibrium data for MgO-SO_2-H_2O and Na_2O-H_2O-SO_2, using a similar technique to that used in Project Number 47 and has also been granted to the University of Washington at a cost of $5000. D. Kotzerke was appointed research fellow on October 1, 1954 and this work is now in process.

3. High Yield Acid Pulping. A questionnaire on high yield acid pulping sent out to all the mills in the industry showed wide interest for more fundamental information on this subject. Two projects are at present being prepared for presentation to the Research Appropriations Committee; one at the Institute of Paper Chemistry to determine the effect of high yield acid pulping on the cellulose and hemicellulose constituents along with the effect of bleaching on yield and physical and chemical properties; and a second one at the University of Washington to determine the effect of high yield acid pulping on the molecular structure of lignin.

4. Spent Sulphite Liquor. Another project ready for presentation to the Research Appropriations Committee is a contemplated study on nonoxidized spent sulphite liquor resulting from normal sulphite cooking. If this work is undertaken, it will be conducted at the University of Toronto, where they will fractionate the alkali-soluble part into groups of compounds of similar pH and solubility, then separate the components of each group by countercurrent distribution and finally identify the compounds isolated. Previous investigations of this type at the University of Toronto have resulted in the identification of several components. This study offers the possibility of finding new sources of raw materials from spent sulphite liquor for the chemical or pharmaceutical industries.

5. 1956 Annual Meeting. Definite plans were discussed for the 1956 annual meeting. The feeling was that the sulphite industry processes are fairly well "cut and dried" and that it is difficult to come up with something new every year.

1. It was decided to review various phases of acid pulping by conducting surveys on sulphur handling, combustion of sulphur, cooling of SO_2 gases, cooking procedures and gas relief, digester circulation, blowing and blow pit treatment.
2. Another subject to be considered as the type of digester lining in use on various bases with particular reference to type of brick, binding materials, and thickness measurements.
3. Papers are to be solicited from mills using bases other than calcium and from mills pulping unusual species of wood.
4. Information is to be obtained from mills making trials with the penetrating agent Petro "P."

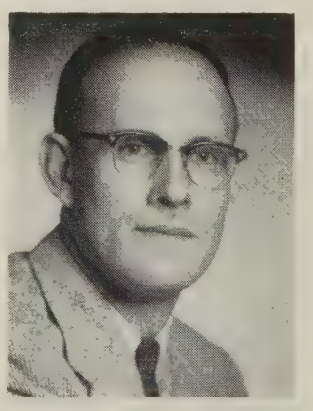
N. S. Lea, *Chairman*

Chemical Methods Committee

Following is a report of the meeting of the TAPPI Chemical Methods Committee held on Feb. 21, 1955, at the Commodore Hotel, New York, N. Y.

1. Changes in the Organization of the Chemical Methods Committee. The chairman announced the appointment of E. S. McColley as vice-chairman, and J. W. Jacokes as secretary.

2. Alpha, Beta, and Gamma-Cellulose in Pulp (T-203 Revision). A new draft was presented for the revision of T-203, which incorporates the most recent suggestions from



N. S. Lea, Scott Paper Co.; Chairman, Acid Pulping Committee

A. S. O'Brien, Eastman Kodak Co.; Chairman, Chemical Methods Committee

the Chemical Methods Committee. This new draft, which is a compromise between the old TAPPI and ACS procedures, will be put into good form and sent out shortly, by Mr. O'Brien, for concurrence by all concerned.

3. New Cold Alkali Solubility Procedure. A new draft was presented for the TAPPI cold alkali solubility method for pulps, which has been under consideration for several months. The proposed method is based on the Swedish Central Laboratory method CCA-8:53. After a few minor editorial changes, the new draft will be sent out by the chairman to members of the Chemical Methods Committee, ACS, and ASTM for concurrence.

Negotiations are under way to find a laboratory equipment supplier who will make available stainless steel stirring equipment of proper specifications, as a stock item.

4. Permanganate Number of Pulp (Revision of T-214). Lyman C. Aldrich will prepare a new draft for the revision of T-214, "Permanganate Number of Pulp." The present method, which is satisfactory for testing pulps with a permanganate number of less than 30, will be extended to cover all pulps by varying the weight of the sample. The volumes of standard permanganate, sulphuric acid, and water will be kept constant. The sample weight will be adjusted so that the quantity of $KMnO_4$ consumed ranges from 32 to 64% of the total added.

The new draft for this method should specify a uniform method of preparing all pulp samples before running $KMnO_4$ numbers. Likewise, it should specify a constant temperature (approximately 25°C.) for all solutions during the analysis.

5. Colorimetric Method for Pentosans in Highly Refined Pulps. Recent investigations to find a suitable method for determining pentosans in highly refined pulps were reviewed.

Mr. Wilson and Mr. McColley will draft a tentative method for pentosans in pulp, which appears acceptable to ACS, ASTM, and TAPPI. When the draft is ready, it will be sent out for concurrence.

The new tentative method will contain two separate procedures—one for high—and one for low-pentosans pulps. Since the present method (T-223) is satisfactory for high-pentosans pulps, it will be used as the basis for one part of the new method. For highly refined pulps with low pentosans contents, an aniline acetate method probably will be used for rapid colorimetric determinations.

6. Chain Length Distribution in Pulps. Prior to the untimely death of Geoffrey Broughton, the investigation which he was making at the University of Rochester on the tentative ACS method for chain length distribution in cellulose had been terminated.

The tentative ACS method for determining chain length distribution in cellulose will be put into TAPPI format and sent out very soon by the chairman to all concerned, for consideration as a suggested method.

7. Accessibility of Pulp. The work which was started by Mr. Broughton, to establish a suggested method for accessibility of pulp, is being continued at the University of Rochester. It was indicated that a suggested method may be ready by June, 1955.

8. Ash in Pulp (Revision of T-211). A joint subcommittee from ACS, ASTM, and TAPPI now is working on a revision of T-211, "Ash in Pulp." It is possible that an ashing temperature of 800°C. will be recommended. The ashing time has not been definitely agreed upon, but will probably be 2 or 4 hours. Platinum crucibles will be specified in the new draft of the procedure.

9. Starch in Paper (Revision of T-419). Jack Harvey reviewed the progress of the work which has been done at the Bureau of Standards to establish a basis for the revision of T-419, "Starch in Paper." It was indicated that the method of Mr. Browning using the starch iodine color is generally satisfactory, but several slight changes were suggested. Mr. Harvey indicated that, very soon he will be ready to put into writing the revision of the procedure for starch in paper.

10. Dye Absorption Technique for Determining Surface Area of Pulps. Mr. Thode described briefly a dye absorption technique which has been found useful in determining surface area of pulps. The procedure could be submitted to TAPPI as a suggested method.

Recently it was found that the bursting strength of pulp handsheets is principally a function of but two variables—the specific dye absorption, and the cupriethylene diamine disperse viscosity of the pulp.

J. W. Jacokes, *Secretary*

Pulp Purification Committee

The Annual Meeting of the Pulp Purification Committee was held in the Grand Ballroom of the Hotel Commodore at 2 p.m. Monday, Feb. 21, 1955, with the following present: W. H. Rapson, Chairman, R. L. McEwen, Secretary, W. Tiller, H. Turner, C. E. Hartford, F. Ernest, J. Schuber, V. Edwardes, E. Ericsson, W. Stengel, R. Husband, F. Kraft, H. W. Giertz (Sweden), H. F. Lewis, W. F. Schroeder, B. G. Hoos, D. H. Baker, and V. Woodside.

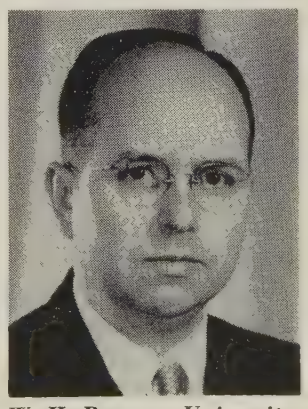
W. H. Rapson and R. L. McEwen were re-elected chairman and secretary, respectively, for another year.

The 1955 TAPPI Annual Meeting symposium on "New Developments in Bleaching" was outlined for the committee. Appreciation was expressed to the subcommittee consisting of W. D. Harrison, R. L. McEwen, and W. H. Rapson for the work of organizing the symposium (held very successfully on Feb. 22, 1955). It was decided that in view of the holding of a symposium this year, next year no symposium would be organized, but miscellaneous papers would be requested related to pulp purification and bleaching generally. The committee should therefore spend more time on the monograph revision details, editing, etc., during the coming year.

It was suggested that Ray Hatch send committee members a status report on the revision of the Pulp Purification Monograph and that committee members send in revisions, etc., to Mr. Hatch at an early date so that this monograph can be issued in a revised edition within the next two years.

The chairman pointed out that the Fundamental Research Committee of TAPPI is sponsoring a symposium of the "Theoretical Aspects of Bleaching," at Appleton, Wis., probably Sept. 15–17, 1955. H. F. Lewis, chairman of the Fundamental Research Committee, was invited to the meeting to elaborate on this, and thought that joint sponsorship by the Pulp Purification Committee would be welcome. The committee agreed to formally offer joint sponsorship to the Fundamental Research Committee.

A discussion of possible committee projects was held. It was suggested that a standard TAPPI method for measuring



W. H. Rapson, University of Toronto; Chairman, Pulp Purification Committee

La Fayette Price, Government Printing Office; Chairman, Paper Testing Committee

pulp brightness reversion is needed, followed by an investigation of the causes of reversion and methods of preventing it. It was agreed that a subcommittee should be appointed to outline the project, seek financial aid from TAPPI, and find someone to carry it out.

The need for an investigation of the relationship of pulping conditions to bleaching results was discussed, but it was felt that this should be referred to the Sulphite Committee and the Alkaline Pulping Committee. The relationship between permanganate number and degree of cooking for various woods, and the correlation of permanganate to bleach demand for these woods was considered too complex a project for the committee to sponsor.

It was concluded that it was impractical to call the committee together more than once a year, but that a meeting may be held at either the Alkaline Pulping Conference planned for Aug. 19–23, 1955, or at the meeting on "Theoretical Aspects of Bleaching" in Appleton, Sep. 15–17, if a sufficient number of committee members are present.

R. L. McEwen, *Secretary*

Pulp Testing Committee

The meeting of the Pulp Testing Committee of TAPPI was called to order at 2:00 p.m. on Feb. 21, 1955, in the Hotel Commodore, New York, N. Y., by Frank Caskey, chairman. Also in attendance were: R. M. Wilkinson, H. A. Smith, B. W. Burgess, G. C. Kimble, H. D. Fisher, J. d'A. Clark, J. Homer Winkler, and J. R. Arthur.

The discussion was opened by Mr. Caskey with a brief progress report as follows:

During the past year much progress has been made in reorganizing the committee. Essentially the plan is to divide the committee into an Eastern Section as well as Western Section in order to facilitate the holding of meetings and thus to create more interest in pulp testing.

Also in the reorganization are newly created subcommittees on Pulp Evaluation (lab beater, ball mill, kollergang, etc., Testing Methods); Dirt in Pulp; Reference Pulp, and Determination of Stock Consistency. The chairman of these subcommittees are, respectively: Norval Magnusson, Elmer Christoferson, Al Graef, and F. A. Delforge.

Progress has been made in all these subcommittees and the results were discussed under the following headings:

Committee Reorganization

The organization of an Eastern Section under the chairmanship of Herb Smith was discussed. This section to include all Eastern, Southern and Middle West committee members plus any additional interested persons from the area, with an attempt to be made to include laboratory pulp testing equipment manufacturers.

It was decided that the Eastern Section should try to hold two meetings per year in addition to the annual meeting in New York and the Fall Testing Conference.

A spring meeting was tentatively set for Friday, April 15, in the Netherland Plaza Hotel, Cincinnati, Ohio, with the thought in mind that those attending might wish to attend the dinner meeting of the Ohio Section of TAPPI at Middletown on Thursday of the same week.

The following projects of special interest to Eastern members were discussed:

Freeness. Glenn Kimble to investigate the possibility of the committee working on the insulating board freeness tester for use with all very free stocks, to overcome some of the shortcomings of the present method in high freeness ranges.

Preparation of Handsheets for Flat Crush Tests. Suggested as a possible project by Mr. Kimble and Mr. Wilkinson.

Stock Consistency. A current project of the entire committee which could be taken over by the Eastern Section.

Reference Pulp Program

Mr. Caskey reported that progress was being made in obtaining standard pulp in 5-lb. packages and in arranging a method of storing and shipping. A discussion was held as to the desirability of obtaining standard beater curves to submit to purchasers of the reference pulp. Doubt was expressed by several members that the program would have much practical value unless some satisfactory method of obtaining such standard curves could be worked out. The matter was deferred for future discussion.

Dirt Count Method I 213 M43

Mr. Caskey reported that the results of the industry-wide check on dirt count had been submitted to the TAPPI Statistics Committee for evaluation and that they had reported statistical requirements had not been met satisfactorily and no conclusions could be drawn as to inherent accuracy of the method. It was the opinion of those present that the dirt count check should be repeated as soon as possible taking care to incorporate methods and safeguards recommended by the Statistical Committee to insure that a valid conclusion be reached.

Stock Consistency

Since Mr. Delforge was not present, no discussion of this project was held.

Freeness

The fact that Canadian Standard freeness correction charts for temperature and consistency put out by the manufacturer now extend to 700 CS freeness whereas TAPPI charts extend only to 500 CS freeness had previously been called to the attention of Mr. Caskey and he asked Mr. Burgess for an explanation. Mr. Burgess reported that the original correction had been worked out on groundwood to 500 CS and that later they were extended to 700 CS on sulphite. He suggested that we hold the matter of revision of the standard in abeyance for the present since the Pulp and Paper Research Institute of Canada, which has responsibility for standardization of the instrument, is now working on a revision of CS methods and the program should be completed in about a year.

The meeting was adjourned at 5:00 p.m. by Mr. Caskey.

J. R. Arthur, *Acting Secretary*

Nonfibrous Materials Testing Committee

Personnel of the Nonfibrous Materials Testing Committee is now as follows:

Keith H. Williams, *Chairman*, Mid-States Gummed Paper Co., 2515 S. Damen Ave., Chicago 8, Ill.

Carl C. Kesler, Penick & Ford, Inc., Cedar Rapids, Iowa.

Thomas S. Morse, Hercules Powder Co., Wilmington, Del.

William R. Willets, Titanium Pigment Corp., 99 Hudson St., New York, N. Y.

Daniel D. Ritson, American Cyanamid Co., 1937 W. Main St., Stamford, Conn.

Milton R. Roberts, St. Regis Kraft Corp., Jackson Fla.

Testing of Rosin and Rosin Size Subcommittee

Thomas S. Morse, *Chairman*, Hercules Powder Co., Wilmington, Del.

R. W. Kumler, Waste Paper Utilization Council, 122 E. 42nd St., New York, N. Y.

Testing of Opaque Pigments Subcommittee

W. R. Willets, *Chairman*, Titanium Pigment Corp., 99 Hudson St., New York, N. Y.

F. H. Denham, R. T. Vanderbilt Co., 33 Winfield St., E. Norwalk, Conn.

H. C. Brill, E. I. du Pont de Nemours & Co., Inc., Newport, Del.

F. O. Sundstrom, American Cyanamid Co., Bound Brook, N. J.

Testing of Animal Glue Subcommittee

C. S. Young, *Chairman*, Swift & Co., U. S. Yards, Chicago, Ill.

R. Tutt, Peter Cooper Corp, Gowanda, N. Y.

L. B. Tucker, Crane & Co., Dalton, Mass.

P. S. Cade, The Harding-Jones Paper Co., Middletown, Ohio.

Testing of Adhesives Subcommittee

Wm. Sederlund, *Chairman*, National Adhesives, 270 Madison Ave., New York 15, N. Y.

L. B. Lane, *Secretary*, Armour & Co., Adhesive Div., 1355 W. 31st St., Chicago 9, Ill.

A. B. Crowell, Jr., Union Paste Co., 1605 Hyde Park Ave., Hyde Park 36, Mass.

W. G. Kunze, Le Page's Inc., 700 S. Caton Ave., Baltimore 29, Md.

L. J. La Brie, Morningstar, Nicol, Inc., 630 W. 51st St., New York 19, N. Y.

Lloyd Perry, Nashua Corp., Nashua, N. H.

Carl Erikson, Arabol Mfg. Co., New York, N. Y.

Wm. Bain, Glidden Co., 5165 W. Moffat St., Chicago, Ill.

Testing Alpha Protein and Soya Subcommittee

W. M. Bain, chairman, Glidden Co., 5165 W. Moffat St., Chicago, Ill.

Because of completion of basic work the subcommittees on Enzymes, Clays, Casein, and Coating Starches are to be dropped from listing with the two above new ones to be added in their place. On Page 36 of Year Book, No. 56, 205, 290 are to be dropped and numbers assigned to the Alpha Protein and Adhesives Subcommittees.

The committee has begun the task of bringing up to date all Standards which are five years old or older. As there are some thirty of these, the following are the first on the agenda: T 600 m-45, T 605 m-44, T 606 m-45, T 608 m-42, T 609 m-42, T 610 m-42, T 612 m-44, T 613 m-44, T 614 m-44, T 617 m-44, T 624 m-44, T 625 m-48.

Consideration is requested for the publishing of a monograph upon the completion of the work of the Testing of Adhesives Subcommittee whose task will be to assemble a body of facts on all types of adhesives and should represent valuable information to paper technicians on selection and use of any known adhesive.

Routine control methods for starch will soon be ready and will be forwarded as soon as possible.

The next meeting of the general committee will be September 28, during the Testing Conference, at the Sheraton-Kimball Hotel, Springfield, Mass.

K. H. Williams, *Chairman*

Plastics Committee

A meeting of the Plastics Committee was held at the Commodore Hotel, New York, N. Y., on Feb. 21, 1955. The following persons were present (35 members): R. T. Nazzaro, Westfield River Paper Co., chairman; J. J. Aid, Robert Gair Co., Inc.; D. E. Baldwin, Westinghouse Electric Co.; S. Batruk, N. J. Zinc Co.; V. A. Belcher, N. J. Zinc Co.; R. E. Benton, Goodyear Tire & Rubber Co.; D. M. Black, Monsanto Chemical Co.; G. L. Booth, Dilts Machine Works; O. P. Cohen, Monsanto Chemical Co.; W. J. Copeland, International Paper Co.; E. F. Egan, Frank W. Egan Co.; P. M. Goodloe, Brown Co.; E. C. Hilkert, Koppers Co.; J. Hussey, Goodyear Tire & Rubber Co.; E. C. Jahn, College of Forestry; F. R. Lehman, Dow Chemical Co.; W. E. Manring, B. F. Goodrich Chemical Co.; W. E. Morris, Barrett Div., Allied Chemical & Dye Corp., O. D. Mosher, International Paper Co.; P. E. Nethercut, Scott Paper Co.; J. E. Parsell, J. P. Lewis Co.; E. J. Paxton, Robert Gair Co., Inc.; J. C. Pullman, American Cyanamid Co.; F. R. Ramage, Latex Fiber Industries; R. W. Reiter, National Starch Products; E. W. Scott, Goodyear Tire & Rubber Co.; R. J. Seidl, Forest Products Laboratory; G. R. Shaw, Taylor Fiber Co.; H. Spector, Naugatuck Chemical Co.; H. A. Spencer, Knowlton Bros.; W. N. Stickel, Texon, Inc.; R. C. Sturkin, Frank W. Egan Co.; W. L. Thomson, E. L. Wiegand Co.; B. R. Whaley, Sonoco Products; and V. T. Stannett, College of Forestry.

The chairman, R. T. Nazzaro, opened the meeting by calling for reports from the two subcommittee chairmen present. Paul Goodloe reported on the activities of the Laminates Subcommittee. The industry had been circulated regarding tests for the resin saturation properties of paper, and after several meetings, it was decided to request a research appropriation to sponsor some simple evaluation tests on suitable saturation test methods in a commercial testing laboratory. The broad purpose for this was to establish a uniform basis for a possible research project on resin bonding and distribution. It was also agreed to hold a symposium on some aspects of paper laminates technology during the Fall Plastics-Paper Conference.

J. C. Pullman then reported for the Paper Converting Subcommittee. The bibliography of the postwar literature on the beater addition of polymers was presently being completed by the members. These would be forwarded to V. Stannett, at the College of Forestry, for assembly into a form suitable for publication in *Tappi*. It was proposed that papers for the Fall meeting should be invited from associations such as the Boxboard Research Association, discussing the requirements of the converting industry from the plastics industry. The chairman of subcommittees were to solicit papers as well by August 1. Mr. Stannett then gave a brief report on the present status and future plans of the permeability project (TAPPI Research Project No. 70). The chairman asked for a vote of approval of the present work, and it was passed unanimously. The present Steering Committee was to continue through 1955 until the next annual meeting.

The Resin Analysis Subcommittee, which had been inactive for some years was dissolved on a motion by the chairman. A motion approving the application for a research appropriation from TAPPI for the resin saturation tests, proposed by the Laminates Subcommittee, was approved unanimously.

The question of the 1955 Fall Plastics-Paper meeting was discussed at some length. It was agreed that a meeting would be held under the aegis of the Polytechnic Institute of Brooklyn, New York, at some suitable date in November, as agreed between the Secretary and Mr. Mark.

J. C. Pullman of the American Cyanamid Co. was voted chairman for 1955 and V. Stannett was re-elected secretary. A vote of thanks was passed for the work of R. T. Nazzaro, the retiring chairman.

The meeting terminated at 4:30 p.m.

V. T. Stannett, *Secretary*

Coating Committee

A meeting of the TAPPI Coating Committee was held on Monday, Feb. 21, 1955, Hotel Commodore, New York, N. Y.

In attendance were: H. O. Ware, acting chairman; J. T. Loomer, Robert Gair Co.; J. D. Lohnas, Newton Falls Paper Co.; J. E. Wilber, St. Regis Paper Co.; N. I. Kennedy, Corn Industries Research Foundation; L. H. Silvernail, Dow Chemical Co.; C. C. Kessler, Penick & Ford, Inc.; A. C. Zettlemoyer, Nat. Printing Ink Res. Institute; H. C.

Brill, E. I. du Pont de Nemours & Co.; K. Craig, Kimberly Clark Corp.; R. B. Williams, Goodyear Rubber Co. Chemical Div.; Don Neese, Goodyear Rubber Co. Chemical Div.; J. E. Ward, Nopco Chem. Co.; R. Wallace, Goodyear Rubber Co. Chemical Div.; A. R. Merritt, Goodyear Rubber Co. Chemical Div.; D. D. Ritson, American Cyanamid Co.; W. R. Willets, Titanium Pigment Corp.; W. M. Bain, The Glidden Co.; E. F. Ritter, The Glidden Co.; R. M. K. Cobb, Lowe Paper Co.; Thomas G. Leek, Morco Co., Division of Bakes Perkins Co.; J. T. Stearn, Consultant, Brooklyn, N. Y.; J. E. Fenn, Consultant, New York, N. Y.; L. W. Egan, Frank W. Egan & Co.; L. G. Landes, American Cyanamid Co.; J. D. Davis, Mead Corp.; C. G. Albert, Minerals & Chemicals Corp.; L. E. Georgevits, Borden Co.; K. M. Gaver, The Ogilvie Flour Mills Co. Ltd.; B. L. Scallet, Anheuser-Busch, Inc.; A. W. Pomber, John Waldron Corp.; J. C. Rice, Lowe Paper Co.; J. W. Swanson, Institute of Paper Chemistry, R. C. Brown, Oxford Paper Co.; H. W. Watson, Polymer Corp. Ltd.; L. J. Paquin, International Paper Co.; H. Lavery, International Paper Co.; R. Hagemeyer, Wyandotte Chemical Co.; J. Thomas, S. D. Warren Co.; A. D. Bonanno, Kelco Co.

H. O. Ware, acting chairman, described to the members the formalizing and function of the Coating Committee Council, the subcommittees and the general Coating Committee of TAPPI.

Coating Committee Council Structure

Office	*Responsibility*	*Present Member*
Chairman	Research Projects	R. T. Trelfa
Vice-Chairman	Data Sheets	H. O. Ware
Senior Member	Testing Methods	J. D. Davis
Secretary	Monographs	A. D. Bonanno
Junior Member	Conferences	J. T. Loomer

Each member will move up one step each year.

1955 Coating Conference Report

Conference Chairman, J. D. Davis
Program Chairman, J. E. Wilber
Exhibits Chairman, Ralph Thompson
Publicity Chairman, L. Silvernail

J. D. Davis gave a summary of the progress made and the present status of the coming 1955 Coating Conference.

J. E. Wilber reported on the tentative program to be presented. Copies of the tentative scheduled program were passed out among the members.

Gerald Haywood was announced to be keynote speaker on pigments.

1956 Coating Conference (J. T. Loomer, *Chairman*)

Plans are underway for a proposed TAPPI Coating Conference to be held in 1956. It was suggested that a possible meeting place could be Philadelphia, Pa., and a possible theme could be synthetic adhesives such as latices, P.V.A., C.M.C., etc. Visits could be made to Hercules Powder Co. and du Pont.

There was some discussion as to what was meant by synthetic adhesives. This subject is still open for definition.

The date for this meeting would be sometime in May, 1956. It was pointed out that this date may conflict with the printing group meeting and should be further looked into.

The 1957 Coating Conference

The following subjects were suggested by the members at large for the 1957 Coating Conference.

(a) Testing of Coatings
(b) Properties of Coated Papers
(c) Unpigmented Coatings
  (1) Latex
  (2) Vinyl Coating
  (3) Etc.
(d) Coating Equipment and Methods
(e) Instrumentation and Analytical Methods

A motion was made by W. R. Willets and seconded by L. Georgevits that questionnaires be sent out to get a general opinion of interest in these subjects. Motion passed.

The following locations were suggested by members as to a possible meeting place for this conference: Bermuda, Mid-west, West, Canada (Toronto), Buffalo, and White Sulphur Springs.

It was suggested that several copies of the proposed questionnaire for the 1957 Conference be sent to each member of the TAPPI Coating Committee so that they in turn could pass them along to their respective company officials and affiliates.

Testing Methods

J. Thomas told the committee members that the data collected were being turned over to J. D. Davis and that he would further cooperate with the affairs of the coating committee.

Data Sheets

H. O. Ware explained the intent and purpose of the data sheets program which the Coating Committee is in the process of formulating.

The following members of the coating committee offered help to H. O. Ware in accomplishing this task: B. L. Scallet, H. W. Watson, J. E. Ward, and A. W. Pomper.

Research Projects

J. Thomas gave a summary on the status of the research project on the Flow Properties of Coating Colors. The work will be done by the University of Maine.

Miss R. M. K. Cobb will cooperate with Mr. Thomas and the University of Maine in following the research project which is now being conducted at the University.

The following members of the coating committee offered to help in projects undertaken by the committee: K. M. Gaver, C. C. Kessler, A. W. Pomper, R. C. Brown, J. C. Rice, and J. G. Leech.

A. D. Bonanno, *Secretary*

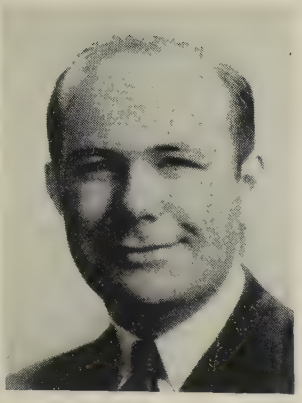
Fourdrinier Committee

The meeting of the Fourdrinier Committee was held on Feb. 21, 1955, at the Commodore Hotel, New York, N. Y.

The chairman, Mr. Phillips, reviewed the program for the Annual Meeting and asked for a vote on the proposition of holding some discussion type meetings during the next year. The committee unanimously voted to have a discussion-type meeting ready for the 1956 Annual Meeting based on questionnaires sent to interested papermakers. It was suggested that the questionnaires be prepared and submitted to the pulp and paper companies by September, 1955, in order that the information might be tabulated and summarized prior to the annual meeting.

The committee then suggested subjects which they felt represented common grounds of interest to the industry. Among the subjects considered by the committee were the following:

(a) What is the maximum freeness for stock that can be used to make a particular sheet?
(b) The effect of the slice jet profile on sheet characteristics.
(c) The causes of "galvanizing" on the wire side of paper.
(d) The advantages and disadvantages of pressure headboxes.
(e) A formula for the placement of top couch rolls in relation to the bottom roll on the wire and presses.
(f) The causes and cures of shadow-marking.
(g) The characteristics of size press roll coverings.
(h) The prevention of grainy edges.
(i) The effect of the fourdrinier wet-end on the dimensional stability of the sheet.



N. R. Phillips, Riegel Carolina Corp.; Chairman, Fourdrinier Committee

F. E. Caskey, Crown-Zellerbach Co.; Chairman, Pulp Testing Committee

(j) The methods and arrangements for drying drier felts.
(k) The effect of the suction pick-up arrangements on the strength and stretch of the sheet.
(l) The optimum vacuum drawn on the sheet by the wire boxes and suction presses.

After considering the suggestions submitted, the committee voted to prepare questionnaires for the 1956 meeting covering (1) the problem of grainy edges, (2) the causes and cures of shadowmarking, (3) the effect of the fourdrinier wet-end on dimensional stability, and (4) the optimum amount of vacuum drawn on the sheet from the headbox to the driers.

R. G. Hitchings, *Secretary*

Preparation of Papermaking Materials Committee

A meeting of the Preparation of Papermaking Materials Committee was held at the Commodore Hotel, New York, N. Y. on Feb. 21, 1955.

The following persons were present:

F. S. Klein, *Chairman*, Byron Weston Co., Dalton, Mass.
E. W. Strecker, Esleeck Manufacturing Co., Turner Falls, Mass.
J. F. Theriault, Robert Gair Corp., Uncasville, Conn.
R. G. Mispley, Crown Zellerbach Corp., Camas, Wash.
W. E. Carlson, Whiting-Plover Co., Stevens Point, Wis.
F. L. Simons, Crane Co., Dalton, Mass.
Norwood H. Keeney, Jr., Lowell Technological Institute, Lowell, Mass.
Harold Joiner, Champion Paper & Fiber Co., Hamilton, Ohio

Filler Monograph. Joe Theriault reported that all of the sections of the filler monograph have been prepared, mimeographed and sent out for review. A review list was compiled largely from manufacturers and dealers of the various types of pigments and was checked with the association headquarters for completeness. The reviewers were given until March 15, 1955, to send in their corrections which in turn will be sent to the individual author for incorporation. It is believed by the 15th of June the author should have completed the correction and the complete monograph will be turned over to TAPPI by approximately July 15. It is hoped and believed that it will be printed by the end of the year.

Beater Additive Subcommittee. Chairman Klein announced that this subcommittee had been formed with Ralph Kumler as chairman. In all probability it will become a complete committee in time. The Steering Committee consists of at present: Ralph Kumler, F. F. Klein, R. G. Mispley, Howard Parker, R. M. Karapetoff-Cobb, J. P. Bainbridge, Jr., and J. C. Barthel.

Basic Procedures for the Preparation of Papermaking Materials. A consensus of the meeting was that a notebook or booklet similar to the TAPPI data sheets on the methods suggested and recommended for preparation of various small materials, such as dyes, wet strength resins, glue, starch, size, etc., would be very useful to the paper industry. In conjunction with this booklet or separate from it, Routine Control Methods for the control of the intermediate materials prepared in the mills was also considered.

Mr. Klein, Norwood Keeney, and John Lewis are to be the nucleus of a subcommittee to study this subject.

John P. Bainbridge, *Secretary*

Preparation of Papermaking Materials Committee Beater Additives Subcommittee

Meetings of the above subcommittee were held on Feb. 20, 1955 at TAPPI Headquarters and on Feb. 21, 1955 at the Hotel Commodore, New York, N. Y.

The following persons were present: Miss R. M. K. Cobb, John P. Bainbridge, Jr., F. S. Klein, R. G. Mispley, Howard Parker (representing D. D. Cameron), and R. W. Kumler, chairman.

The first meeting of the Beater Additives Subcommittee took place at TAPPI headquarters on Sunday, Feb. 20, 1955 at 2:00 p.m. Three subjects were discussed at considerable length, viz:

1. The writing of a Monograph on Sizing. It was agreed that R. W. Kumler would endeavor to draw up a plan of procedure and submit to the members of the steering committee in writing.
2. A research project on the effect of pulping on sizing. R. G. Mispley is to draw up a research project and submit at his earliest convenience.
3. The testing of paper for sizing. Miss Cobb has been requested to formulate a research proposal on size testing.

Originally two subjects had been proposed for discussion at this meeting.

1. The writing of a critical review of the literature on sizing.
2. A discussion of size testing methods.

It was felt that the literature review would be such an undertaking that its completion would be far in the future. Furthermore some writing could be just as well ignored in summing up the known information on the subject. Nevertheless it was agreed that the committee could well begin its work by writing down the present status of knowledge of the subject of sizing.

It was felt that in order to distribute the work so that no one would be overburdened, the subcommittee should be enlarged. The names of a number of people were proposed. The planning of this venture will require considerable time and thought and R. W. Kumler agreed to draw up a plan in consultation with F. S. Klein for submission to the committee members by mail.

In discussing projects to be sponsored by the subcommittee, R. G. Mispley called attention to the fact that two pulps made from the same wood species by the same general pulping process may behave very differently toward sizing chemicals. In other words, seemingly minor changes in pulping procedures greatly affect the sizing characteristics of the pulps produced. The reasons for this are not known. The committee therefore agreed to consider this as a research project. R. G. Mispley will draw up a proposal for submission to the steering committee.

The testing of paper for degree of sizing was discussed but no conclusions reached on February 20. It was generally felt that the confusion that exists regarding the various sizing tests would seriously hamper research on sizing procedures. At the same time it was recognized that reconciliation among the various testing methods would be a long time coming if ever. For the research on the effect of pulp char-

R. W. Kumler, Waste Paper Utilization Council; Chairman, Beater Additives Subcommittee

F. A. Simmonds, Forest Products Laboratory; Chairman, Dissolving Pulp Committee

acteristics it was decided to use several test methods and express conclusions in terms of each.

Further discussion among Messrs. Klein, Mispley, Bainbridge, and Kumler took place on Monday, February 21, at the Commodore Hotel. It was agreed to consider a research project on size testing. One suggestion was to study the factors influencing pen and ink tests. Later Miss Cobb was asked to formulate a project somewhat along these lines.

R. W. KUMLER, *Chairman*

Dissolving Pulp Committee

A meeting of the Dissolving Pulp Committee was held on Feb. 21, 1955, at the Commodore Hotel, New York, N. Y.

Members and others interested in this committee who attended the meeting were:

Harold Bice, E. I. du Pont de Nemours & Co., Inc., Indiana Ordnance Works, Charlestown, Ind.
James M. Corday, E. I. du Pont de Nemours & Co., Inc., Penns Grove, N. J.
J. H. Greene, Industrial Rayon Corp., Cleveland, Ohio, representing Emil Kline
Merle A. Heath, Buckeye Cotton Oil Co., Memphis, Tenn.
John P. Hollihan, Rayonier Inc., New York, N. Y., representing Edwin L. Lovell
William A. Kraske, Celanese Corp. of America, New York, N. Y., representing Morris Wayman
Albert T. Maasberg, Dow Chemical Co., Midland, Mich.
William P. Manley, Hercules Powder Co., Hopewell, Va.
Roland C. McCully, Armour Research Foundation, Chicago, Ill.
Douglas H. McMurtrie, Brown Co., Berlin, N. H.
William H. Monsson, Hooker Electrochemical Co., Niagara Falls, N. Y.
Wayne E. Moore, Forest Products Laboratory, Madison, Wis.
P. J. Muffatt, Ecusta Paper Corp., Pisgah Forest, N. C.
Mark Plunguian, Southern Chemical Cotton Co., Chattanooga, Tenn.
Jerome F. Saeman, Forest Products Laboratory, Madison, Wis.
Milton O. Schur, Ecusta Paper Corp., Pisgah Forest, N. C.
F. A. Simmonds, *Chairman*, Forest Products Laboratory, Madison, Wis.
Richard W. Swinehart, Dow Chemical Co., Midland, Mich.

Committee officers selected for 1955 are: chairman, F. A. Simmonds; vice-chairman, Merle A. Heath; secretary, Forestier Walker.

Regretfully, the Committee announces the resignations of Peter Van Wyck, Station Director, Hercules Powder Co., Experiment Station, Wilmington, Del., and Harold Bice (see foregoing list). Mr. Van Wyck was a charter member. Mr. Bice had replaced R. S. Apple of the du Pont Burnside Laboratory at Penns Grove, N. J., who was also a charter member. The committee welcomes to membership James M. Corday (see foregoing list) and Fred K. Mesek, Johnson & Johnson, Chicago, Ill. Mr. Corday replaces Harold Bice.

As its chief activity for the past year, the committee developed a program comprising a session of four papers of general interest in its field and a symposium of four papers on viscose filtrability. The latter was sponsored by the Viscose Subcommittee under the chairmanship of Milton O. Schur.

A similar program is planned for the 1956 Annual Meeting, the subject selected for the symposium being "The Evaluation of Dissolving Pulps." Messrs. Heath and Swinehart are responsible for the symposium and Walker and Simmonds for the session of general interest papers. Individuals interested in taking part in this program are urged to submit titles as soon as possible.

The scope of the committee as given in the current Year Book was reaffirmed. A uniform scope, based on end usage, was adopted for present subcommittees, namely, "The Preparation and Requirements of Pulps for Chemical Conversion; the Study of the Processes of Conversion." These subcommittees and chairmen are as follows:

Acetate: Mark Plunguian
Nitrate: To be appointed
Methyl and C.M.C.: Richard W. Swinehart
Viscose: William P. Manley

The chairmen are to complete the organization of the subcommittees for the development of projects.

The Committee chairman reviewed the responsibilities of TAPPI committees to conduct research projects and to prepare Standards, Data Sheets, and Monographs. In this connection, it was recognized that complete carbohydrate analysis is important in the evaluation of dissolving pulps and end products and that advancements in chromatographic techniques for this purpose clearly indicate possibilities for standardization. For these reasons, it was resolved that a recommendation be made to the Chemical Methods Committee that they consider sponsorship of a study of these techniques for the purpose of developing a TAPPI Standard.

Personnel of the Dissolving Pulp Committee is now as follows:

Forrest A. Simmonds, *Chairman*, Forest Products Laboratory, Madison 5, Wis.
Merle A. Heath, Vice-Chairman, The Buckeye Cotton Oil Co., Memphis 18, Tenn.
Forestier Walker, *Secretary*, American Enka Corp., Enka, N. C.
Roe C. Blume, E. I. du Pont de Nemours & Co., Inc., Waynesboro, Va.
Lloyd M. Cooke, The Visking Corp., Chicago 38, Ill.
Sidney Coppick, American Viscose Corp., Marcus Hook, Pa.
James M. Corday, E. I. du Pont de Nemours & Co., Inc., Penns Grove, N. J.
C. V. Holmberg, State University of New York, College of Forestry, Syracuse 10, N. Y.
E. J. Howard, Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada
J. Warner Jacokes, American Enka Corp., Enka, N. C.
Emil Kline, Industrial Rayon Corp., Cleveland, Ohio
Edwin L. Lovell, Rayonier, Inc., Shelton, Wash.
Albert T. Maasberg, The Dow Chemical Co., Midland, Mich.
William P. Manley, Hercules Powder Co., Hopewell, Va.
Earl S. McColley, Celanese Corp. of America, Rock Hill, S. C.
C. Roland McCully, Armour Research Foundation of Illinois Institute of Technology, Chicago 18, Ill.
Douglas H. McMurtie, Brown Co., Berlin, N. H.
Fred K. Mesek, Johnson & Johnson, Chicago, Ill.
W. H. Monsson, Hooker Electrochemical Co., Niagara Falls, N. Y.
H. deVere Partridge, Alaska Pine & Cellulose Co., Woodfibre, B. C., Canada
Mark Plunguian, Southern Chemical Cotton Co., Chattanooga, Tenn.
L. N. Rogers, Buckeye Cotton Oil Co., Memphis, Tenn.
W. E. Roseveare, E. I. du Pont de Nemours & Co., Inc., Richmond 12, Va.
Milton O. Schur, Ecusta Paper Corp., Pisgah Forest, N. C.
M. Wayman, Columbia Cellulose Co., Ltd., Prince Rupert, B. C., Canada

Subcommittee on Cellulose Acetate
Mark Plunguian, *Chairman*, Southern Chemical Cotton Co., Chattanooga, Tenn.
Subcommittee on Methyl Cellulose and CMC
Richard W. Swinehart, *Chairman*, The Dow Chemical Co., Midland, Mich.
Subcommittee on Cellulose Nitrate
To be appointed
Subcommittee on Viscose
William P. Manley, *Chairman*, Hercules Powder Co., Hopewell, Va.
Sydney Coppick, American Viscose Corp., Marcus Hook, Pa.
Edward J. Howard, Industrial Cellulose Research, Ltd., Hawkesbury, Ont., Canada
Mark Plunguian, Southern Chemical Cotton Co., Chattanooga, Tenn.
Richard W. Swinehart, The Dow Chemical Co., Midland, Mich.
Forestier Walker, American Enka Corp., Enka, N. C.

FORESTIER WALKER, *Secretary*

Electrical Engineering Committee

Personnel of the Electrical Engineering Committee is now as follows:

M. J. Osborne,* *Chairman*, Bowaters Southern Corp., Calhoun, Tenn.
R. R. Baker,* *Secretary*, Westinghouse Electric Corp., East Pittsburgh, Pa.
R. E. Crossley, *Vice-Chairman*, Great Northern Paper Co., Millinocket, Me.
H. B. Barrows, General Electric Co., Atlanta, Ga.
D. E. Bivins, The Brown Paper Mills, Monroe, La.
S. A. Bobe, Westinghouse Electric Corp., 1299 Northside Drive, Atlanta, Ga.
N. L. Danforth,* St. Regis Paper Co., Bucksport, Me.
T. E. Digby, Container Corp. of America, P. O. Box 748, Fernandina, Fla.
R. W. Foster,* Champion Paper & Fibre Co., Canton, N. C.
T. Foulkes, E. B. Eddy Co., Hull, P. Q., Canada
J. L. Grady, Oxford Paper Co., Rumford, Me.
E. F. Greive,* Allis-Chalmers Mfg. Co., 4620 Forest Ave., Norwood 12, Ohio
C. L. Harvey,* Elliott Co., Ridgway, Pa.
C. J. Meloun,* General Electric Co., Schenectady, N. Y.
A. O. Mortenson,* St. Regis Paper Co., P. O. Box 1591, Pensacola, Fla.
G. L. Oscarsen,* Electric Machinery Co., Minneapolis, Minn.
G. Shaad,* General Electric Co., Schenectady, N. Y.
R. F. Sorensen, Union Bag & Paper Corp., P. O. Box 570, Savannah, Ga.
M. M. Stokley, J. E. Sirrine Co., Greenville, S. C.
M. Strain, Continental Paper Co., Ridgefield Park, N. J.
H. C. Swannell,* J. E. Sirrine Co., Greenville, S. C.
J. L. Van Nort,* Reliance Electric & Eng. Co., Cleveland, Ohio
I. Witham,* Byron Weston Co., Dalton, Mass.

On Monday, Feb. 21, 1955, a meeting of the Electrical Engineering Committee was held. The meeting was called to order by the committee chairman, M. J. Osborne. J. L. Van Nort tendered his resignation as secretary, and R. R. Baker was appointed to take over these activities.

Robert Crossley agreed to accept the appointment as vice-chairman of the committee.

It was suggested that a member be proposed from one of the West Coast properties, and Mr. Baker will investigate and make recommendations.

The following TAPPI members were guests at the committee meeting: N. O. Wardell, Carthage Machine Co.; A. J. Stockslager, Reliance Elec. & Mfg. Co.; and E. R. Bucklacher, Allis-Chalmers Mfg. Co.

Committee Meetings

The Electrical Engineering Committee holds two regular scheduled meetings each year: In New York City during February in connection with the Annual Meeting of the Association, and in the Fall at the Annual Engineering Conference, which meetings are held at various cities throughout the United States and Canada. Additional meetings are held by subcommittees throughout the year as required to carry on the work of these subcommittees.

Committee Projects

The 1954–55 TAPPI Yearbook lists the projects undertaken by the Electrical Engineering Committee. The present status of each of these projects is as follows:

Project No. 358—Power Requirements for Paper Machines. The committee initial report on this project was made at the Fourth Engineering Conference held in Boston in 1949. A copy of the report appears in the *Tappi*, vol. 33, pp. 113–116 and 116–117. The information contained in this report was reduced to TAPPI Data Sheets in the series 145-F-G-H-I. As a continuation of this project, it was proposed to bring this power data up to date in the following manner:

(a) Preparing a suitable questionnaire to collect the operating power data on both cylinder and fourdrinier type paper machines.
(b) Arranging to have copies sent to a selected group of mills, preferably those who operate sectional drives and who maintain corporate membership in the Association.
(c) Applying for a TAPPI Research Appropriation to permit collecting and coordinating this power data.

Continuation of Project No. 358—Fourdrinier Section Load Requirements. The final committee report on this project was made at the Engineering Conference, Savannah, Ga., in the year 1951, and the final report was published in *Tappi*, vol. 35, No. 8, pp. 337–342. The committee has not as yet approved this power data for a data sheet revision. Data Sheets 145F-G-H-I still appear as originally published.

Continuation Project No. 358—Power Requirements of the Press Section. The final report on this project was made at the Engineering Conference in Chicago in 1952. This report has been published in *Tappi*, vol. 35, No. 9, pp. 390–394. Revised data sheet material has been prepared on this subject and these data have been referred to the Data Sheets Committee.

Project No. 359—The Selection of Electric Motors for Paper Mill Applications. The report on this project was made at the Fifth Engineering Conference held in Cincinnati, Ohio, in 1950. It is suggested that publication in *Tappi* should be made as soon as possible.

Project No. 368—Power Requirements for Supercalenders. A committee report was made on this project at the Ninth Engineering Conference held in Philadelphia in 1954. A final report on the power requirements of supercalenders is to be completed by Aug. 1, 1955, and circulated to the entire Electrical Engineering Committee. If acceptable, it will be approved as data sheet material at the Tenth Engineering Conference to be held in Houston in the Fall of 1955. After approval, the material will be sent to the Data Sheet Committee for proper preparation of a new data sheet.

Project No. 369—Application of Electric Cable. The final committee report was presented at the Seventh Engineering Conference in Chicago in 1952. The report was published and appears in *Tappi*, vol. 36, pp. 161A–163A.

Data covering this project have been prepared and presented to the Data Sheet Committee for publication. Mr. Maloun should report progress.

Project No. 433—Selection of Chipper Drives. The final committee report on this project was made at the Ninth Engineering Conference in Philadelphia in 1954. This report is presently being reviewed by members of the committee before being forwarded to Mr. Bingham for publication in *Tappi*.

From the material as covered by the committee report, data sheets are being prepared indicating two methods for selecting chipper drives.

As a continuation of the project, the committee decided to have Mr. Wardwell investigate the possibilities of obtaining further field test data covering power requirements of the chipper as affected by the chipper design during the coming

* Present at February 21 meeting.

year. Any such data collected will be submitted to the committee for further consideration.

Project No. 434—Application and Design Characteristics of AC Motor Control. A final report on this project was made at the Ninth Engineering Conference in Philadelphia in 1954. Copies of this report have been submitted to Mr. Bingham for publication. It is not the intention of the committee to prepare data sheets of this information.

Project No. 435—An Engineering Analysis of Down Time on Electrical Sectional Drives. A report was made on this project at the Ninth Engineering Conference in Philadelphia in 1954. The preliminary report of the committee appears in *Tappi*, vol. 37, No. 6, on page 249. A form for recording paper machine down time on sectional electric drives is being prepared. It has been suggested that Mr. Sorensen prepare sufficient copies of the down time form so that they can be given to all members of the committee with a request for written comments to be available for the next engineering conference in Houston, Tex. After the down time form has been reviewed and approved, it will be turned over to Mr. Maloun for publication by the Data Sheet Committee.

Project No. 468—Location and Causes of Motor Failures. The 1954–55 yearbook listed Project No. 468 and indicated that Ray Chermak had been appointed chairman of a subcommittee to cover the activities in connection with this project. The committee has had no report on the activities of this subcommittee.

Electrical Engineering Committee Projects for Listing in the Yearbook. The committee made the following recommendations for additions to the projects to be listed in the yearbook:

1. Pulp and paper mill power distribution: S. A. Boge, chairman, Westinghouse Electric Corp.; H. B. Greear, General Electric Co.; H. C. Swannell, J. E. Sirrine Co.; and Doc Emmons, Westinghouse Electric Corp.

2. Commutation problems of the paper mill: D. E. Bivins, Jr., chairman, Brown Paper Co.; H. B. Barrow, General Electric Co.; I. Witham, Byron Weston Co.; and J. L. Grady, Oxford Paper Co.

3. Preventive maintenance for paper mill electrical rotating machinery: N. L. Danforth, chairman, St. Regis Paper Co.; R. E. Crossley, Great Northern Paper Co.; J. L. Grady, Oxford Paper Co.; and R. W. Foster, Champion Paper & Fiber Co.

Tenth Engineering Conference, Houston, Tex., Fall, 1955. The Committee is proceeding with the following schedule:

Subject	*Author*
Main Session:	
1. Preventive Maintenance for Paper Mill Rotating Machinery	N. L. Danforth
2. Paper Mill Lighting Design and Economics	H. C. Swannell
Discussion Session:	
3. Pulp and Paper Mill Power Distribution Part I	S. A. Bohe
4. Commutation Problems of the Paper Mill	D. E. Bivins, Jr.
5. Down Time of Electrical Sectional Drives	H. F. Sorenson

AIEE Pulp and Paper Subcommittee Joint Meeting. Mr. Bobe has suggested a joint meeting with the AIEE members and members of TAPPI during the Tenth Engineering Conference at Houston. The dates of the Tenth Engineering Conference are set as October 31 and November 1–3. Five of the Electrical Engineering Committee members indicated an interest in such a meeting if it could be held after the regular TAPPI meetings on Friday, November 4. No doubt a very interesting program could be prepared which would be of mutual interest to both the AIEE and TAPPI membership. Mr. Osborne should notify Mr. Bobe of our interest in such a joint meeting.

Preparation of Papers for Publication in Tappi. The following papers are being considered for publication in *Tappi:*

1. "Drier Bearing Problem as Encountered at the American Coating Mills." This paper approved for publication. Mr. Osborne to forward copies to Mr. Bingham.

2. "DC Testing of High Voltage Cable." Mr. Shaad will make copies and circulate to the committee membership for comments and approval.

3. "Magnetic Amplifiers in Paper Mills." Paper to be prepared by M. H. Fisher, Westinghouse Electric Corp. Mr. Baker will forward copies to committee members for comment and approval.

R. R. Baker, *Secretary*

Data Sheets Committee

A meeting of the Data Sheets Committee was held at the Commodore Hotel, New York, N. Y., on Monday, Feb. 21, 1955. The following men attended the meeting:

C. J. Meloun, representing Electrical Committee
H. F. Parker, representing Mill Maintenance Committee
F. D. Helverson, representing Industrial Engineering Committee
A. J. Chase, representing Chemical Engr. Committee
J. W. Wilson, representing Drying & Vent. Committee
R. V. Pennington, Jr., Corrosion
A. J. Winchester, Secretary
J. W. Hemphill, Chairman

Absent: Roland A. Packard, P. L. Nelson, E. D. Jones, and G. B. Brown.

General Discussion. The chairman reviewed the work that had been accomplished by the committee since the Philadelphia meeting in October and spent some time explaining and discussing the use and application of the sets of Data Sheets that had been recently sent to all the members. He also explained the use of the Functional or Process Index (yellow pages) that accompanied the sets of Data Sheets. It was pointed out that it is the direct responsibility of the members of this committee to study those areas of the Index that come under their control and give us subjects for Data Sheets so that we can really begin functioning.

Under discussion of the mechanism of handling proposed Data Sheets, it was restated that all Data Sheets issued must show the date of issue and that all Data Sheets that eventually are reissued should show date of sheet which the present sheet supersedes.

In reviewing the functioning of the Data Sheet Committee, it was once again pointed out that this committee's function is to receive the Data Sheets from the various subcommittees, edit these sheets, approve them and finally see that these Data Sheets are issued. It is the function of the subcommittees on Data Sheets to actually produce the Data Sheets.

It was suggested that if possible, all lettering on the Data Sheets should be done with a Le Roy pen or similar type pen, using TAPPI standard lettering where possible.

In the circularizing of Data Sheets for approval, it is necessary that those who do not approve the Data Sheet should state clearly their objection to the sheet and, if possible, give alternate suggestions. It was felt that the Data Sheets should be sent around to the various committee members until it has either had total approval, or all parties feel that the data contained on the sheet are essentially correct.

With regard to the publishing of Data Sheets, it was the unanimous opinion of the Committee that after each Data Sheet is finally approved and ready for publication, it should appear in *Tappi* as soon after approval as possible.

The accumulated Data Sheets published in the magazine during any one year will be reprinted in loose-leaf form and issued to all the members of TAPPI at the end of each year.

The report of each member on the work of his committee was particularly satisfactory, even though there was some misunderstanding as to certain requirements. Mr. Helverson submitted his data sheets on "Screw Conveyer Operation." Mr. Chase had some misunderstanding regarding the data

but will have his into the secretary's hands very quickly. Mr. Wilson is still studying the psychrometric charts and will undoubtedly, have the data sheets available for us as soon as he can get some matters cleared away. Mr. Parker submitted three sets of data sheets. Mr. Pennington turned over a rather complete set of data sheets on "Inspection of Digesters." Mr. Meloun has completed the data sheets on "Chipper Power Curves." Mr. Jones, although not present had already submitted his data sheets to the secretary.

It was agreed that all members of this committee advise the secretary of their projects for 1955 by March 31, of this year. We feel that this matter of having projects is very important as otherwise very little if anything is ever accomplished.

The possibility of having a meeting between now and October was discussed but it was felt that we had better not attempt a summer meeting due to vacations and other factors.

J. W. Hemphill, *Chairman*

Structural Fibrous Materials Committee

Personnel of the Structural Fibrous Materials Committee is now as follows.

Main Committee:
R. G. Lacy, *Chairman,* Celotex Corp.
J. J. Perot, *Secretary,* Flintkote Co.
V. M. Anderson, Fir Tex Insulation Board Co.
H. L. Becher, Homasote Co.
J. F. Campbell, Flintkote Co.
A. H. Chamberlain, Bird & Sons
G. H. Chidester, Forest Products Laboratory
L. Eberhardt, Bauer Brothers Co.
E. Frederick, Jr., Celotex Corp.
D. L. Gleaves, National Gypsum Co.
E. M. Jenkins, Johns-Manville Corp.
C. Larson, Minnesota & Ontario Paper Co.
W. D. MacKinnon, Donnaconna Paper Co., Ltd.
W. J. Marshall, Insulation Board Institute
T. R. Naffziger, Northern Regional Research Lab.
W. L. Scott, Armstrong Cork Co.
G. W. Thomas, Wood Conversion Co.
R. S. von Haznburg, U. S. Gypsum Co.
A. T. Walton, Simpson Logging Co.

Subcommittees:
S-0 Steering
R. G. Lacey, *Chairman,* Celotex Corp.
J. J. Perot, Flintkote Co.
G. W. Thomas, Wood Conversion Co.
E. M. Jenkins, Johns-Manville Corp.
S-1 New Projects and Reviews
C. Larson, *Chairman,* Minnesota and Ontario Paper Co.
J. J. Perot, Flintkote Co.
E. J. Reichman, Simpson Logging Co.
S-2 Papers and Publications
J. F. Campbell, *Chairman,* Flintkote Co.
E. M. Jenkins, Johns-Manville Corp.
G. W. Thomas, Wood Conversion Co.
S-3 Test Board Formation
R. G. Lacey, *Chairman,* Celotex Corp.
A. H. Chamberlain, Bird & Sons, Inc.
D. L. Gleaves, National Gypsum Co.
T. R. Naffziger, Northern Regional Research Lab.
S-4 Drainage Time Testing
E. M. Jenkins, *Chairman,* Johns-Manville Corp.
J. J. Perot, Flintkote Co.
C. E. Hrubesky, Forest Products Laboratory
W. D. MacKinnon, Donnaconna Paper Co. Ltd.
S-5 Coated Properties of Decorative Coated Fiber Board
E. A. Lauring, *Chairman,* Minnesota & Ontario Paper Co.
J. F. Campbell, Flintkote Co.
W. J. Marshall, Insulation Board Institute
R. S. von Haznburg, U. S. Gypsum Co.
S-6 Water Absorption, Water Penetration and Water Vapor Permeability
R. D. Ziegler, Washington State College
A. T. Walton, Simpson Logging Co.
V. M. Anderson, Fir Tex Insulation Board Co.
J. J. Erchul, Pioneer Flintokote Co.
S-7 Nail Holding-Racking Test
R. H. Neisel, *Chairman,* Johns-Manville Corp.
E. M. Cagle, Flintkote Co.
A. H. Chamberlain, Bird & Sons, Inc.
W. C. Lewis, Forest Products Laboratory
W. L. Scott, Armstrong Cork Co.
S-8 Light Reflection Measurement
W. L. Scott, *Chairman,* Armstrong Cork Co.
H. B. Carson, Fir Tex Insulation Board Co.
E. J. Jones, Celotex Corp.
M. C. Miller, Johns-Manville Corp.
S-9 Consistency Measurement of Insulating Board Pulp
A. H. Chamberlain, *Chairman,* Bird & Sons, Inc.
G. E. Chamberlain, Minnesota & Ontario Paper Co.
W. H. Graham, Johns-Manville Corp.
R. J. Seidl, Forest Products Laboratory
S-10 Rate of Drying of Insulating Board
L. Eberhardt, *Chairman,* Bauer Brothers Co.
F. R. Hyatt, Johns-Manville Corp.
H. Becher, Homasote Co.
S-11 Relation of Finished Board Properties to Wet Lap and Stock Characteristics
G. W. Thomas, *Chairman,* Wood Conversion Co.
H. Becher, Homasote Co.
W. H. Graham, Johns-Manville Corp.
W. D. MacKinnon, Donnaconna Paper Co., Ltd.

Annual Report 1955

S-0. Steering Committee. The Steering Committee completed tentative plans for the February, 1956 meeting. Several papers based on completed projects will be available.

S-1. New Projects and Reviews. Four new projects were assigned during the year: (1) Coating Properties of Coated Fiberboard (to S-5), (2) Evaluation of Sizing Materials for Use in Insulating Board (to S-9), (3) Rate of Drying of Insulating Board (S-10), (4) Relation of Finished Board Properties to Wet Lap and Stock Characteristics (S-11).

S-2. Papers, Publications, and Reports. Not enough material was available to justify SFME sponsorship of a general program. Several projects are nearing completion and should provide papers for the 1956 meeting. These should be prepared and submitted as soon as possible.

S-3. Test Board Formation. Evaluation of the board forming equipment was completed by Celotex. The equipment is now being circulated to other insulating board manufacturers for their evaluation. A paper is planned for the 1956 meeting. This will present complete details of the operation and evaluation of the equipment.

S-4. Drainage Time Testing. The two SFMC drainage time testers are being circulated to interested laboratories for evaluation. One tester is now at Celotex and the other at Simpson Logging Co.

The Laurel Machine and Foundry Co. has offered to supply testers at $450 each. Anyone interested in purchasing a tester can obtain complete details by contacting J. F. Campbell, The Flintkote Co., Meridian, Miss.

S-5. Transverse and Deflection Testing. This project has been completed and test procedures drawn up. The committee has been assigned a study of coating properties of coated fiberboard.

S-6. Water Absorption, Water Penetration & Water Vapor Permeability. Work is continuing on this project.

S-7. Nail Holding and Raking Tests. The objective of this assignment is the correlation of small scale tests with large-scale racking tests. An investigation of available facilities has been made but no testing has been done. Results of tests of this type made by one of the insulating board manufacturers are to be circulated to the members of the subcommittee for their review.

S-8. Light Reflection Measurement. The subcommittee will prepare a progress report detailing the work that has been done on this project.

S-9. Consistency Measurements on Insulating Board Pulps. A suggested method has been drawn up. The subcommittee will subject it to a critical laboratory evaluation before submitting it as a standard.

S-10. Rate of Drying of Insulating Board. The subcommittee was given the above assignment and will start work at once.

S-11. Relation of Finished Board Properties to Wet Lap and Stock Characteristics. The subcommittee was given the above assignment and work will begin at once.

Small Scale Tunnel Test—Forest Products Laboratory. Design work on a small scale tunnel has been completed. Correlation tests are in progress. Duplicate samples will be tested in the large Underwriters' laboratory tunnel, the small tunnel, the SS-A-118b method and by a radiant panel test.

The ASTM Task Force will report in May on the status of this work. Mr. Scott is requested to forward this report to the secretary for distribution.

Election of Officers. The following officers were elected for a one-year term: R. G. Lacey, Chairman, and J. J. Perot, Secretary.

General. The following schedule of dates for bimonthly reports was set up. All subcommittee chairman should submit their reports to the Secretary two weeks *prior* to the following dates: May 1, July 1, September 1, November 1, January 1

J. J. Perot, *Secretary*

TAPPI-ASTM Technical Committee on Petroleum Wax

Advisory Section

G. C. Borden, Jr., Riegel Paper Corp., Milford, N. J.
Robert Dannenbrink, Marathon Corp., Menasha, Wis.
R. M. Koppenhoefer, 412 Greenpoint Ave., Brooklyn 22, N. Y.
P. J. Metz, Western Waxed Paper Co., San Leandro, Calif.
J. W. Padgett, Moore & Munger, 33 Rector St., New York, N. Y.
Frans Vaurio, Institute of Paper Chemistry, Appleton, Wis.
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Q. W. Weaver, Scott Paper Co., Chester, Pa.
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Miles A. Joanen
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G. C. Borden, Jr., Riegel Paper Corp., Milford, N. J.

Section VIII—Scuff and Gloss

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Joseph Walker, Pure Oil Co., Research & Dev. Labs., Crystal Lake, Ill.
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H. C. Moyer, Sinclair Rfg. Co., Research & Dev. Dept., 400 E. Sibley Blvd., Harvey, Ind.
J. W. Padgett, Moore & Munger, 33 Rector St., New York 6, N. Y.
W. R. Turner, The Atlantic Rfg. Co., 2700 Passyunk Ave., Philadelphia, Pa.
D. R. Cushman, Socony-Vacuum Labs., 412 Greenpoint Ave., Brooklyn 22, N. Y.
E. W. Midlam, Cit-Con Oil Corp., P. O. Box 1578, Lake Charles, La.
R. Rosenbaum, Semet-Solvay Div., Allied Chemical & Dye Corp., 40 Rector St., New York 6, N. Y.
Frans Vaurio, Institute of Paper Chemistry, Appleton, Wis.
M. V. Hunter, Calif. Research Corp., P. O. Box 1627, Richmond, Calif.
E. W. Sanders, Cities Service Oil Co., East Chicago, Ind.

General Committee

Producers

Company	Representative	Address
1. Atlantic Refining Co.	A. C. Smith, Jr.	2700 Passyunk Ave., Philadelphia 1, Pa.
2. Bareco Oil	H. H. Coffman	P. O. Box B, Barnsdall, Okla.
3. Cit-Con Oil Corp.	E. W. Midlam	P. O. Box 1578, Lake Charles, La.
4. California Research Corp.	E. W. Gardiner	200 Bush St., San Francisco, Calif.

5. Cities Service Research & Development Co.	E. W. Sanders	Cities Service Technical Lab., East Chicago, Ind.
6. Commerce Oil Corp.	Harry R. Lewis	445 Park Ave., New York, N. Y.
7. Compagnié Française de Raffinage*	D. S. Volkmar	c/o F. Van Acker, 610 Fifth Ave., New York 20, N. Y.
8. Continental Oil Co.	W. F. Dowling	Ponca City, Okla.
9. Gulf Oil Corp.	R. P. Daniels	P. O. Box 701, Port Arthur, Tex.
	(P. R. Templin)	Gulf Research & Development, P. O. Box 2038, Pittsburgh, Pa.
10. Mid-Continent Petroleum Corp.	W. L. Thompson	P. O. Box 381, Tulsa, Okla.
11. Moore & Munger	John W. Padgett	33 Rector St., New York 6, N. Y.
12. National Wax Co.	Cliff Swett	1300 W. Division St., Chicago, Ill.
13. Petrolite Corp., Ltd.	A. W. Marshall	505 Buchanan, Longview, Tex.
14. Phillips Petroleum Co.	W. Nelson Axe	Research Dept., Bartlesville, Okla.
15. Pure Oil Co.	R. J. Askevold	Research & Development Labs., Crystal Lake, Ill.
16. Quaker State Oil Refining Corp.	R. W. Geiser	Research Lab., Emlenton, Pa.
Shell/Koninlijke Laboratorium*	W. M. Mazee	Amsterdam, The Netherlands
17. Shell Oil Co.	W. J. Yates	50 W. 50th St., New York 20, N. Y.
	(G. P. Hinds)	Houston Refinery, Box 2527, Houston, Tex.
18. Sinclair Oil Co.	N. J. Gothard	Control Lab., 400 E. Sibley Blvd., Harvey, Ill.
19. Socony Vacuum Oil Co.	(J. B. Rather, Jr.)	412 Greenpoint Ave., Brooklyn, N. Y.
	R. M. Koppenhoefer	412 Greenpoint Ave., Brooklyn, N. Y.
20. L. Sonneborn Sons, Inc.	Joseph Phillips	Petrolia, Pa.
	A. Kinsel*	300 4th Ave., New York, N. Y.
	(H. Levkoff)*	300 4th Ave., New York, N. Y.
21. Standard Oil Co. (Ind.)	J. A. Bolt	Box 431, Whiting, Ind.
22. Standard Oil Co. (Ohio)	W. E. Scovill	Midland Bldg., Cleveland 15, Ohio
23. Standard Oil Development Co.	H. L. Yowell	Esso Labs., P. O. Box 51, Linden, N. J.
	(I. E. Manning)	Bayonne, N. J.
24. Sun Oil Co.	S. W. Ferris	Marcus Hook, Pa.
25. The Texas Co.	(R. A. Wheeler)	Research & Technical Dept., Box 1490, Port Arthur, Tex.
	R. H. Thurston	135 E. 42nd St., New York, N. Y.
26. Tide Water Associated Oil	Vincent J. Tkac	Research & Development Dept., Bayonne N. J.
27. Union Oil Co. of Calif.	Stanley P. Backlund	Research Div., Brea, Calif.
28. Universal Oil Products Co.	A. E. Hoffman	310 S. Michigan Ave., Chicago 4, Ill.
29. American Petroleum Institute	W. T. Gunn	

* Nonvoting.

Consumer and General Interest

Company	Representative	Address
1. Albemarle Paper Co.	F. D. Gothwald, Jr.	Richmond 17, Va.
2. American Can Co.	J. R. Wright	11th Ave. & St. Charles Rd., Maywood, Ill.
3. Badger Paper Mills, Inc.	J. A. Hanson	Pestigo, Wis.
4. Bell Telephone	Kenneth G. Coutlee	Murray Hill, N. J.
5. Commonweath Color and Chemical Co.	G. D. Fronmuller	3240 Grace Ave., New York 67, N. Y.
6. Central Waxed Paper Co.	W. R. Price	5659 W. Taylor St., Chicago 44, Ill.
7. Diamond Match Co.	Herbert P. Jacques	Plattsburg, N. Y.
8. Dixie Cup Co.	John G. Kressman	Laboratory Adhesives & Wax, Easton, Pa.
9. Ex-Cello-O Corp.	J. D. Crawford	14310 Hamilton Ave., Detroit, Mich.
10. Fabricon Products, Inc.	G. H. Argue	1721 Pleasant Ave., River Rouge, Mich.
11. Fibreboard Products, Inc.	H. S. Gardner	Research & Development Div., P. O. Box MM, Antioch, Calif.
12. General Foods Corp.	Milton Yezek	Post Cereals Div., 275 Cliff St., Battle Creek, Mich.
	E. A. Yermakoff	Central Labs., 11th and Hudson, Hoboken, N. J.
13. Institute of Paper Chemistry	Frans Vaurio	Appleton, Wis.
14. Kalamazoo Vegetable Parchment Co.	M. W. Kane	Kalamazoo 99, Mich.
15. Marathon Corp.	Robert Dannenbrink	Menasha, Wis.
16. Minerva Wax Paper Co.	Joseph Thompson	Grant St., Minerva, Ohio
17. Nashua Corp.	Lloyd M. Perry	44 Franklin St., Nashua, N. H.
18. Nekoosa-Edwards Paper Co.	T. A. Pascoe	Port Edwards, Wis.
19. Newark Paraffine & Parchment Paper Co.	Miss Lillian Grelecki	50 Jelliff Ave., Newark 8, N. J.
20. Pollock Paper Corp.	C. James Johnson	2236 S. Lamar St., Dallas 2, Tex.
21. Provincial Paper, Ltd.	J. R. Gunning	Georgetown Div., Georgetown, Ont., Canada
22. Pyroxyline Products, Inc.	P. H. Yoder	Paoli, Pa.
23. Army Quartermaster Military Planning Comm.	Lois Hans	Office of the Quartermaster General, Washington 25, D. C.
24. Rap-in-wax Paper Co.	Harlan V. Anderson	150 26th Ave., S. E., Minneapolis 14, Minn.
25. Rhinelander Paper Co.	R. W. Reed	Rhinelander, Wis.
26. Riegel Paper Corp.	George C. Borden, Jr.	Milford, N. J.

27. E. S. & A. Robinson	George C. Acheson	Laird & Esander Drives, Leaside, Tor., Canada
28. Scott Paper Co.	Q. C. Weaver	Chester, Pa.
29. H. P. Smith Paper Co.	L. F. Swec	5001 W. 66th St., Chicago 38, Ill.
30. Technicarbon Co.	A. A. Lant	85 Sargeant St., Holyoke, Mass.
31. Western Wax Paper Co.	P. J. Metz	2199 Williams St., San Leandro, Calif.
32. Allied Chemical & Dye	R. Rosenbaum	P. O. 88, Tonawanda, N. Y.

A meeting of Advisory Section and section chairmen of the TAPPI-ASTM Technical Committee on Petroleum Wax was held on Feb. 23, 1955, at the Commodore Hotel, New York, N. Y.

Vote on Test Methods. The Advisory Section voted to confirm the letter ballot of the General Committee recommending publication of:

(a) Proposed Method of Test for Blocking Point of Paraffin Wax by ASTM as a proposed method for information only, and by TAPPI as a suggested method.
(b) The proposed procedure for Oxidation Stability of Paraffin Wax by TAPPI as a suggested method.

Committee and Section Officers. The tenure of committee and section officers which had been set at approximately two years at our September, 1953 meeting was reconsidered in the light of our experience since that time, and the experience of other ASTM and TAPPI technical committees.

It is now believed that two years is normally too short a term, and that the terms should be for a minimum of two years with no maxium specified. The length of office would normally vary in individual circumstances, and would be determined by the activities of the office and the circumstances of individual office holders.

Lengthening the term of office will have some bearing on previous ideas regarding appointment of a chairman-elect for each of the sections, although the basic idea of having two officers for each section remains unchanged. In view of the longer tenture of officers, it will probably be preferable to refer to the alternate in the section as secretary rather than chairman-elect, although there should normally be an understanding that the secretary will ultimately take over the chairmanship. Arrangements for appointing the secretary should be made by section chairmen, after first, however, submitting several names to the secretary of the general committee for consideration by the advisory section; review of prospective officers by the advisory section will serve to permit better coordination between sections in appointment of officers, and is in keeping with ASTM and TAPPI practices.

Membership. The Vanity Fair Paper Mills, Inc., of Plattsburg, N. Y., have taken over the wax paper interests of the Diamond Match Co. Vanity Fair Paper Mills wish to take over the membership of the Diamond Match Co. in the TAPPI-ASTM Technical Committee on Petroleum Wax with Herbert F. Jacques remaining as committee representative. A motion to this effect was placed before the advisory section and approved.

Section Meetings. Means of improving the effectiveness of section meetings and activities were reviewed as a continuing item. No new ideas were advanced although the section chairman felt that further emphasis should be placed on early reporting of results of test programs. Further consideration will also be given to drawing up agenda for section meetings so as to streamline the meetings as far as possible. It was noted that the schedule for this year's meetings did not allow sufficient time in some cases, and arrangements will be made next year to allow more time to cover the agenda.

It was noted that a uniform system for numbering of samples under test is not currently used. It was proposed and agreed that such a system would be desirable, and hereafter samples will be numbered by a code letter followed by a number, such as A-5. In this system the letter will correspond to the number of the section, i.e., "A" will be Section I, "B" Section II, etc., and the number will refer to the sample number. These numbers will be provided by the section chairmen.

Section I—Strength Tests

Subsection A—Tensile Strength. Tabulated results were distributed on the latest two round robins on (a) the effect of aging time after pouring the wax, and (b) the effect of solubility of mold release compound on paraffin-micro blends. Aging for periods over two hours caused no significant changes in tensile strength, and the section decided to retain the two-hour aging period currently specified. Tests with mold release compounds confirmed earlier findings that such materials decrease the tensile strength of blends of paraffin and microcrystalline wax, and showed that this effect is due to surface action rather than to solubility of mold release compounds in the wax blend. Two new test programs were set up (1) using mold release compound applied from a solvent dilution and (2) a study to show the effect of cooling rate after pouring. The section decided to take no action at present on a suggestion to designate the modified Dow mold as an alternate equipment to the Mellon modified Perkins mold in the published procedure.

Subsection B—Bending Tests. The current round robin on modulus of rupture is not complete, since the wax samples were only recently distributed. After completion of the current tests, a new round robin will be conducted, using new blades for cutting the wax specimens.

Section II—Glow Characteristics

The meeting of Section II was devoted to a discussion of certain modifications to be made in the present method of measuring the penetration of petroleum wax, and to the direction of the future work of the group. The section felt that a questionnaire should be circulated to the wax consumer members of TAPPI concerning their needs in the way of a penetration test, and also the other flow properties of waxes in which they are interested. This will be done in the near future.

Section III—Stability Tests

At the meeting of Section III—"Stability Tests" on Tuesday morning, Feb. 22, 1955, announcement was made that TAPPI-ASTM Technical Committee had approved recommending the method of test for Oxidation Stability of Paraffin Wax (Peroxide Method) for publication by TAPPI as a suggested method. The section voted to submit the method to letter ballot for publication by ASTM for information only. Also, it agreed to establish precision data, so that the status of the method could be changed to that of tentative standard by both TAPPI and ASTM. In addition, the section decided to pursue the study of the use of indigo dyes in lieu of the peroxide method of reaching an induction period end point. It was also decided to make a preliminary study of an oxygen absorption method for measurement of stability.

Section IV—Sensory Tests

The data accumulated from the wax odor round-robin conducted since the October meeting was discussed. It was pointed out that within-laboratory agreement at various odor levels was fairly good. Between-laboratory agreement, however, was rather poor.

Each participating laboratory was invited to discuss the comments made at the time the odor round-robin was conducted.

The following conclusions were reached:

1. The present odor scale is satisfactory.
2. Wax odor should continue to be judged on an intensity scale rather than to introduce terms descriptive of odor type.

Future work of the committee will be conducted on these points:

1. Determine methods for choosing odor panel members.
2. Investigate means of preparing samples for odor testing.
3. Check odor level of prepared samples after different storage periods.
4. Various methods for reporting test results from odor panels.
5. Standardization of odor bottle size.
6. Possibility of synthesizing odor standards.

Section V—Composition

TAPPI Standard T 634 m53, Melting Point of Petrolatum. Section V voted to recommend certain changes in the subject method, the principal effects of which will be to extend the title to cover microcrystalline waxes, and to change thermometers and temperatures to encompass higher melting materials. The proposed revisions will next be submitted to the general committee for letter ballot.

Precision of ASTM Method D721-53T, TAPPI T-636m, Oil Content of Petroleum Waxes. The section voted to change the reproducibility of the subject method, for oil contents under 2%, from 0.20% to 0.25%, and recommended that the general committee be balloted on this.

Need for establishing better uniformity in the porous filter sticks furnished by different suppliers for use in this method was agreed upon by the Section. The Atlantic Refining Co.'s method for acceptance of filter sticks was favorably received, and the chairman was instructed to communicate with the chairman of Subcommittee 26 of ASTM E-1 on Filtration Materials to determine their views concerning adoption of this procedure.

Cooperative Program on ASTM D 87–42 (TAPPI T 630 m48), Melting Point of Paraffin Wax. During the Oct. 6, 1954, meeting it was agreed to circularize some wax samples for the purpose of obtaining precision data on "stirring" versus "no stirring" in D 87. If stirring can be eliminated, the ASTM and TAPPI tests can be made identical with that of IP. The program has not yet been implemented, but this will be done in time to have data available for the next meeting.

Reaffirmation of Standards and Tentatives. By voice vote, the section voted that Methods D 87–42, Melting Point of Paraffin Wax, D 127–49, Melting Point of Petrolatum and Microcrystalline Wax and D 612–45 Carbonizable Substances in Paraffin Wax be reaffirmed without change. Method D 721–53 T is recommended for reaffirmation as a tentative subject, however, to a change in the precision section which must be letter balloted by Technical Committee M. Section V does not feel that D 721–53 T should be advanced to Standard in view of the anticipated addition of a porosity test specification on filters.

Section VI—Blocking

The membership reviewed the results of the current round-robin tests on two waxes. These waxes were run on four different days by each laboratory. The repeatability within the laboratories was good, and the reproducibility between laboratories was within accepted limits. Preblocked strips were evaluated by Section members and general agreement as to "pick point" and "50% block point" was excellent.

The TAPPI-ASTM Technical Committee on Petroleum Wax has voted to approve publication of our present proposed procedure for information only by ASTM and as a Suggested Method by TAPPI. Several comments were discussed, but the method will be released for publication with no major changes at this time. A few minor and editorial changes will be made to conform to TAPPI and ASTM format, but the general conditions of test will remain unchanged.

A general survey of existing coating equipment in the membership will be made, the subcommittees will be appointed to investigate different variables.

Standard samples will be announced for availability and the manufacture of standard test equipment will be investigated.

John Kressman of Dixie Cup Co. presented a new blocking point procedure. This is known as the "Wafer Test Method of Determining the Blocking, Gloss Retention, and Flow Characteristics of Petroleum Waxes." Copies of the procedure were distributed for the membership information and further consideration.

Section VII—Sealing and Laminating

A brief review of the data presented at the October, 1954 meeting in Dayton, Ohio, indicated that the main source of variation in sealing strength tests was in the preparation of waxed paper strips rather than sealing and strength testing procedures. A new round-robin was set up whereby each member would prepare waxed strips and follow the sealing and testing procedure on 3 separate days, repeating the waxing step in each case. Those members having the 60° angle tester were requested to test their samples with this apparatus also.

An additional round-robin was established whereby waxed strips prepared in two laboratories, with surface coating weights of 2, $3^1/_2$, and 5 lb. per ream, would be distributed to the members, who would seal and test them.

A separate investigation is to be made by one of the committee members on the use of other paper stocks, in order to find a paper which might bring out greater differences in sealing strength of the waxes.

No action was taken for the present on studying effects of quick chilling, but the desirability of future action was indicated.

Section VIII—Gloss and Scuff

Gloss. The subject of the gloss research project was discussed with reference to what has been accomplished since an appropriation for the project was first requested. The original proposal included having R. S. Hunter travel to each of the companies who submitted waxed paper samples in order to obtain a visual gloss rating of the samples, for use in designing a glossmeter which will correlate with visual ratings. The section voted unanimously to adopt a proposal eliminating the travel portion of the project. A revised request for an appropriation will be submitted to TAPPI based upon this change, and also taking into consideration work that has been done in this field in the interim.

Scuff. Results of scuffing strips of various lengths were reviewed. Use of longer strips may be advantageous, but would involve alteration of the present scuff tester, and this will be held up pending further study of the suitability of electro-typed blocks, as referred to below.

W. R. Turner presented a brief summary of the work he has done on the electro-type reproduction of the scuffing blocks. The grooves in the blocks so reproduced are not as deep as the original blocks, but appear to be deep enough for our purposes. The cost of making the electro-type blocks was estimated to be $25, and delivery could be made in about 2 months. All members present voted in favor of obtaining the electro-typed blocks, and to conduct a round robin to determine whether or not the various laboratories could obtain good agreement with the new blocks.

Unless there is an extended delay in obtaining the scuff blocks, the deadline for returning results will be June 1, 1955. This will permit the analysis of data and its distribution prior to the September meeting.

W. J. Yates, *Secretary*

Alkaline Pulping Committee

The Alkaline Pulping Committee met at the Commodore Hotel, New York, N. Y., on Sunday, February 20 with a full attendance. Malcolm Pineo presided and opened the meeting at 2:00 p.m. The report of the previous meeting was read and approved.

Business of the committee was discussed:

1. Fall meeting was confirmed for Chattanooga with a

visit to Bowaters. Tentative dates of around October 19 to 21 were agreed on.

2. The past fall meeting in Birmingham was discussed. From this discussion necessary motions were made to present a resolution to the Executive Committee covering the handling of conferences. The resolution was duly drawn and presented.

3. A suggestion was made to ask Mr. Elderkin to appoint a local arrangement chairman for the fall conference in Chattanooga. This was handled as suggested. The person appointed will become a member of the committee.

4. The project of the Lignin-Chlorine Subcommittee was discussed. This project is concluded and the work completed and reported.

5. R. H. Stevens reported for the Testing Procedures Subcommittee. They are considering the Potentiometric method for sulphides in black liquor. A method for solids in black liquor, and several other suggested testing methods. Mr. Stevens is working out a formal report.

6. *Bibliography.* The yearly literature survey of alkaline pulping by The Institute of Paper Chemistry for the committee has been abandoned as operated in the past. Further bibliographies will not be prepared by the Institute.

7. Mr. Pesch reported on the possibilities of the development of methods for completely analyzing white and black liquor as well as the importance of these methods to the industry. This project was started at the fall conference in Birmingham. Mr. Pesch's report is given below.

Chairman Pineo appointed Mr. Pesch chairman of a subcommittee for this project and Mr. Pesch selected the following members of the subcommittee: R. Fuller, J. Limerick, V. Woodside, and H. Y. Charbonnier.

A motion was made, seconded, and passed as follows: Alkaline Pulping Committee through its chairman contact the Research Appropriations Committee and the Executive Committee regarding the advisability and possibility of making this subject a TAPPI research project.

8. The possibility of monographs, TAPPI standards, and data sheets was discussed. Robert Fuller was appointed to investigate the possibilities and to follow up on the discussion.

9. Committee membership was discussed and the resignation of Al Yundt reluctantly accepted. Possible new members were proposed and the chairman requested to contact them.

10. Additional committee meetings were considered. It was decided the present two meetings a year were sufficient.

11. The following leaders were elected for the coming year: Malcolm Pineo, chairman, H. Y. Charbonnier, vice-chairman, Robert R. Fuller, secretary, David Wetherhorn, fall program chairman.

12. Those present were: A. P. Yundt, R. H. Stevens, Vernon Woodside, E. A. Harper, Robert E. Bowen, David Wetherhorn, H. Y. Charbonnier, Fred W. Bishop, K. G. Chesley, Jack Limerick, Jack Winchester, M. P. Pineo, K. D. Running, A. W. Pesch, and Robert R. Fuller.

R. R. Fuller, *Secretary*

Chemical Analysis of Sulphate Cooking Liquor

At the meeting of our Committee at Hotel Tutwiler in Birmingham, Ala., in connection with the TAPPI Alkaline Pulping Conference in October, 1955, I accepted your assignment to the effect that I investigate ways and means for developing suitably accurate and practicable methods for the complete chemical analysis of the digester cooking liquor of the sulphate process.

In my opinion these desired methods of analysis should cover all of the "inorganic" constituents that normally are, or may be, present in the white liquor and black liquor of the sulphate and soda pulping processes, including the major components, as well as the minor and trace components heretofore not customarily analyzed for, such as sodium, potassium, calcium, magnesium, iron, aluminum, chromium (from chrome refractories), zinc (from rayon salt cake and rayon Glauber's salt), silicon, copper, sulphur, chlorine, fluorine (from certain "salt cakes" and waters), phosphorus, et cetera.

The methods of analysis should cover not only the determination of the various elements that are (or may often be) present, but also their calculation to the compound forms in which they probably exist in the liquors concerned.

In this whole matter I, personally, am not so much concerned with the effects that certain major and minor liquor components have (or just possibly may have) on the pulp in the alkaline cooking process; but I am personally very much of the opinion that certain of the minor liquor components, *or their absence today as compared to the period prior to 1935–40*, may be very important with regard to the accelerated rate of digester corrosion which so many sulphate mills have experienced during recent years.

The following are most of the changes which have been suggested as definitely, or possibly, being connected with this increased rate of sulphate digester corrosion:

1. Changes in the methods of producing the steels used for digesters.
2. Changes in the methods of fabricating digesters.
3. Substantial increases in the average size of sulphate digesters.
4. Important changes and advancements in sulphate pulp mill "auxiliary" equipment, such as in the washer room, evaporator room, recovery room, caustic room, and process water treatment plants, some of which changes have resulted in noticeable changes in white liquor composition.
5. Changes in sulphate mill operation, due very largely to equipment changes and developments such as those enumerated under Item (4) above.

The TAPPI Digester Corrosion Subcommittee has devoted a great deal of time and effort to the study of the digester corrosion problem, but I feel, personally, that their work has been hampered a great deal by the fact that no mills, or almost no mills, have any adequate records on the composition of their digester liquors prior to the period 1935–40. Practically no such data are available either for the period since that time. That lack of data is due to the absence heretofore, of any general feeling that these data might be very important, or to the lack of time and opportunity in the mill laboratories, plus the fact that convenient and dependable methods of analysis were and still are, not available.

I know that the content of sodium sulphate in the white liquor at many sulphate mills is substantially lower today with modern spray furnaces, than it was in the old rotary and smelting furnace days. The presence of sodium sulphate in the water inside steam boilers is desirable in order to inhibit caustic embrittlement. Caustic embrittlement is admittedly due to intergranular corrosion. That evidence makes it logical to believe that the presence of more sodium sulphate in the digester liquors might reduce digester corrosion, other things being equal. I realize that we have long had an adequate analytical method for determining sodium sulphate, but we have usually applied that method only for determining and reporting the per cent reduction (green liquor or smelt) without bothering to determine and to record the sodium sulphate content of the white liquor.

We hear a lot of talk about the supposed accelerating effect of high sulphidity on digester corrosion. But the fact is that in the days when most sulphate mills used from about 300 to over 600 lb. of salt cake per ton of pulp, the sulphidity of the white liquor averaged higher than today, and the digesters lasted longer. In those old days the white liquor was usually much yellower than today, not the pale greenish yellow of today but a deep reddish yellow or orange. My guess is that the content of sodium polysulphides was substantially higher in the old days when the digesters were admittedly corroding much less rapidly. Around a year ago a statement by a technical representative of one of the major U. S. sul-

phate pulp producers was published, saying in effect that sodium polysulphide inhibits digester corrosion. We have never had an adequate method for determining the polysulphides and certain other sulphur compounds in pulp mill liquors. I have seen some unpublished data by an important U. S. steel producer which indicates that sodium monosulphide, Na_2S, is a very important corrosive agent in sulphate digesters.

Sodium chloride, NaCl, may be present in white and black liquors in substantially greater amounts today than formerly and this may be significant in sulphate digester corrosion. Sodium chloride sublimes more readily in the recovery furnaces than sodium carbonate and sodium sulphate. Before the installation of Cottrell precipitators, the soda stack losses were probably an important avenue for the escape of sodium chloride from the system. Cottrell precipitators, however, obviously return most of the sublimed sodium chloride to the system. I know of one mill where representative Cottrell dust, on the oven-dry basis, averaged about one-seventh (about 14%) sodium chloride content. Very few mills have been analyzing their process liquors for chlorides. Their determination in white, green, and black liquor presents some difficulties.

Whether or not going from soapstone to chrome refractory furnace linings has resulted in any changes in the minor and trace components of white liquor I simply do not know.

From purely personal observations I believe that white liquor today usually contains less suspended lime mud when it reaches the digesters than in the days before the same mills had modern continuous causticizing systems.

Based on considerations such as those outlined above, I suggest that the Alkaline Pulping Committee request a research appropriation for studying the analysis of white, green, and black liquors by an adequate agency, to the point where accurate, convenient and practicable analytical methods for all of the inorganic components, including sulphur in all of its forms so far as practicable, shall have been worked out, tested in practice, and published. I also suggest that a subcommittee, under the Alkaline Pulping Committee be formed, that they take this matter under their wing, and that they maintain an adequate liason with the Corrosion Committee.

A. W. Pesch

RECENT BOOKS

Pulp and Paper Manufacture. Vol. 4. Edited by J. Newell Stephenson. McGraw-Hill Book Co., New York, 1955. Cloth, 6 × 9, 732 pages. $9.

The fourth and final volume of the industry's textbooks on pulp and paper manufacture is now available and will meet a very important need of the industry.

The series have been prepared under the direction of the Joint Textbook Committee of the United States and Canada and presented the most up-to-date detail of all phases of pulp and paper manufacture.

Volume 4 deals specifically with auxiliary paper mill equipment. Since there is no other series of texts on the subject of equal importance this review will mention the subjects covered, together with the names of the various chapter authors as follows:

1. Instrumentation and Process Control
   J. N. Franklin, Bowaters Paper Co.
   Vance P. Edwardes, formerly of International Paper Co.
   J. McK. Limerick, Bathurst Power & Paper Co.
   W. R. Nelson, Green Bay Paper & Pulp Co.
   R. H. Doughty, Fitchburg Paper Co.
2. Pumps, Pumping Apparatus and Agitating Equipment
   T. Agronin, Black-Clawson Co.
   J. W. Hemphill, Johns-Manville Corp.
3. Materials Handling
   G. R. Wadleigh, formerly of the West Virginia Pulp & Paper Co.
4. Heating and Ventilation
   W. K. Metcalf, J. O. Ross Engineering Co.
5. Steam
   W. A. D. Clark, A. L. Stewart, K. D. Sheldrick, and R. A. Hanright
6. Water
   Hervey J. Skinner, American Conditioning House
7. Electrical Equipment
   W. G. Gibson, R. G. Bell, H. E. Stafford, R. J. Ungradt, and S. F. Wolferston
8. Bearings and Lubrication
   E. B. Wardle

The above-mentioned authors were but a few of the individuals who collaborated in the preparation of the text, consultation and review of the text. The editor marshalled a corps of experts who were generous in their effort to produce a text that will be of maximum value to the operators and students of the pulp and paper industry.

The four volumes are outstanding in every respect. They represent the combined effort of more than 300 men prominent in the industry.

The previous volumes covered: (1) Preparation and Treatment of Wood Pulp ($10); (2) Preparation of Stock for Paper Making ($7.50); and (3) Manufacture and Testing of Paper and Board ($11).

The Nation Looks at Its Resources. Resources for the Future, 1145 Nineteenth St., N. W., Washington, D. C. Paper, 7 × 10, 418 pages. $5.00.

The report of the Mid-Century Conference on Resources for the Future held in Washington, D. C., on Dec. 2–4, 1953. All phases of the subject were considered by a very large gathering of representatives of industry, education, government, and labor (1600 persons). In 1908 a similar conference was held. The scope of the conference can be estimated by the wide variety of subjects covered such as: competing demands for the use of land, utilization and development of foods, fibers, timber and forest products, wildlife, water, minerals, energy, world resources and resources research. The text is made up largely of statements by many individuals on the subjects discussed.

Water Conditioning for Industry. By Sheppard T. Powell, Consulting Engineer. McGraw-Hill Book Co., New York, 1954. Cloth, 6 × 9, 548 pages. $9.00.

Mr. Powell, the author, is a member of TAPPI and a well-known authority on water engineering problems. The present volume deals with modern treatment and conditioning methods. Emphasis is placed on the preparation of water for high-pressure boilers.

Among the subjects covered are: settling, chemical coagulation, flocculation, softening, design and operation of evaporators, deaeration of feedwater, recirculation systems, steam contamination, corrosion, caustic embrittlement, boiler scales, chemical cleaning, and miscellaneous treatments. The book is amply illustrated.

Chemical Calculations, 6th Ed. By H. V. Anderson, Lehigh University. McGraw-Hill Book Co., New York, 1955. Cloth, 6 × 9, 305 pages. $4.75.

An unusually useful handbook to be used as a supplement to other tests on chemistry to work out most problems dealing with the subject as it is met in practice.

Some of the subjects are significant figures, specific gravity, percentage concentration, valence, formula writing, percentage composition, the gram-atom and gram-mol, temperature, gas laws, mol-weight-gas volume relations, boiling and freezing points, derivation of chemical formulas, chemical equations, oxidation-reduction, gram-equivalency, thermochemistry, electrochemistry, chemical equilibrium, reversible reactions, and solubility-product principle.

A Manual of Paper Chromatography and Paper Electrophoresis. By Richard J. Block, New York Medical College, Emmett L. Durrum, Walter Reed Army Medical Center, and Gunter Zweig, Charles F. Kettering Foundation. Academic Press, New York. Cloth, 6 × 9, 484 pages. $8.00.

A review of chromatography and the basic principles and methodology of paper electrophoresis. All of the important procedures are described in detail for both qualitative and quantitative methods for the benefit of research chemists.

By chromatography is meant those processes which allow the resolution of mixtures by effecting separation of some or all their components in concentrated zones or in phases different from those in which they are originally present, irrespective of the nature of the force or forces causing the substances to remove from one place to another.

The method of paper partition chromatography consists of applying a small drop of the solution containing the substances to be separated to a slip of filter paper a short distance from one end. The drop is allowed to dry, and the end of the paper nearest to the spot is placed in the developing solution, usually a water-containing organic solvent, so that the solvent flows past the "spot" by capillary action and on down the length of the paper.

The book covers the theoretical phases of the subject and provides details for determining amines, proteins, carbohydrates, aliphatic acid, steroids, purines, phenols, aromatic acids, and miscellaneous organic substances.

Although the techniques described are of special interest to medical chemists, more and more research chemists in all fields are acquainting themselves with these new techniques—new except that Phiny, in early times, described the use of papyrus impregnated with an extract of gall nuts for the detection of ferrous sulphate.

Practical Formulary. By Mitchell Freeman of the Mitchell Laboratories. Chemical Publishing Co., New York, 1955. Cloth, 6 × 9, 400 pages. $7.95.

There have been a number of practical formulary books prepared by different authors. Although the information furnished is rather heterogeneous, much of it is of value in everyday life. Copies of such books are found in the libraries of research laboratories where investigators find need for hundreds of hints to meet the many unexpected contingencies that arise in work requiring creative effort and ingenuity.

The present volume covers such topics as alloys, bleaches, cements, glues, cleaning preparations, soaps, disinfectants, inks, lacquers, plastic wood, qualitative and quantitative tests, stain removers, waterproofing, and fireproofing.

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International Journal of Abstracts on Statistical Methods in Industry. Issued by International Statistical Institute, 2 Oostduinlaan, The Hague, Netherlands. 6 × 9, 78 pages. Vol. No. 2. Three issues annually, $2.50; single issues, $1.00.

Photo-offset reviews of articles on statistics appearing in various industrial and scientific publications.

Note: Copies of books reviewed in this section may be obtained from the Book Department of The Technical Association of the Pulp and Paper Industry, 155 E. 44th St., New York 17, N. Y.

EMPLOYMENT SERVICE

Positions Wanted

E301-55. Chemical Engineer; 34, married; 9 years' pulp and paper experience in supervisory, development, and control work. Acid and alkaline pulping, book and bond paper. Desire position with opportunity and challenge in supervisory or development work with a progressive company.

E303-55. Development Engineer, M.E. degree 1937, extensive successful experience in research, development, design, and manufacture of high-speed automatic production machinery, conveyorized process equipment, blanking presses and dies, feeding devices, coating, laminating, winding and slitting machines, printing presses. Experienced engineering supervisor and assistant chief engineer. Exceptional background in paper converting industry, bags, file folders, corrugated storage files, paper cups and containers, product design, automation. Age 38. Seek challenging position in engineering or production management. Excellent references.

E304-55. Chemical or Equipment Sales Executive. Technical education. Eighteen years' experience in pulp and paper manufacturing, development of paper chemicals, sales promotion, and market research. Familiar with application and performance of most chemicals and equipment in the paper industry. Seeking job with broader future. Salary required over $12,000 per year.

E305-55. Mechanical Engineer. Age 39. Ten years' experience plant and maintenance engineering, five years civil engineering. Would be most valuable to an expanding mill where construction planning and supervision experience could be used as well as routine mill engineering. Presently employed in a paper mill.

Positions Open

P437-55. Major Boxboard Producer and Converter needs technically trained man. Must have at least two years' experience in board mill operation or in coating of board or paper. Experience in machine or off machine coating acceptable.

P438-55. Chemist, age 26 to 40, with a B.S. degree in Chemistry or Chemical Engineering, who has had 2 to 5 years' experience in paper manufacturing, for development and control work in medium-sized, progressive paper mill located in the Miami Valley. Good opportunity, many desirable fringe benefits, excellent working conditions. Good starting salary. Send résumé, with photograph, and salary requirements.

P439-55. Chemical Engineer. To work in technical department of new and expanding bleached pulp mill in Southeastern North Carolina. Must have from 3 to 6 years' experience in pulp manufacture. Salary commensurate with qualifications. Please make résumé as complete as possible and submit recent photograph. Riegel Carolina Corp., Acme, N. C.

P444-55. Coating Chemist. Excellent opportunity for graduate chemist or chemical engineer with experience in clay coating of enamel and machine coated printing papers. Must be capable of organizing plant scale development work. Location—Mid-West.

P446-55. Man with technical education and production experience for Assistant Technical Director with opportunity to transfer to Production Manager or Mill Manager. Fine papers and specialties. At least ten years' experience necessary. Write giving experience and salary expected.

P447-55. Corrugator Engineers wanted. A long-established manufacturer of corrugated box-making machinery offers secure employment to engineers experienced in the design and operation of corrugated machinery.

RESEARCH CHEMIST FOR LIGNIN STUDIES

Ph.D. or equivalent, experienced in wood chemistry particularly with regard to lignin and its derivatives.

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Air conditioned laboratories and offices located on outskirts of Corpus Christi, Texas. Responses should include complete résumé of background and experience. Mail to:

Celanese Corporation of America
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P449-55. Project Chemist or Engineer. The long range expansion program of an integrated board, carton, and container manufacturer provides opportunity to the young chemist or engineer seeking a career in production supervision. Indoctrination and training for eventual supervision will be handled on a special project basis in laboratory and mill scale experimental work for process improvement. Address reply to J. A. Connolly, P.O. Box 3611, San Francisco 6, Calif.

Note: Responses to all advertisements should, unless otherwise indicated, be sent to TAPPI, 155 E. 44th St., New York, N. Y.

Graduate Chemist wanted for research and development work in the field of lacquer coated papers and plastic films. Excellent opportunity to build a secure future in young and fast growing company. Salary open. Address replies to: Research Director, Plastic Coating Corp., Holyoke, Mass.

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TAPPI DATA SHEETS

Handling Extruded Plastic Packings

TAPPI Data Sheet 78 F

(THIS DATA SHEET IS UNDER THE JURISDICTION OF THE ENGINEERING RESEARCH AND MACHINE DESIGN COMMITTEE)

When ordering spiral plastic packings, specify approximate shaft diameters so that spirals may be formed to near correct diameters. This will avoid excessive distortion of rings cut from the spiral. For example, a packing formed to a 3-in. I.D. spiral could be used with minimum distortion on shafts from 2 to 4 in. diameter.

Use tight square butt joints—do not allow for expansion.

When placing rings over shafts, open them sideways to get them over the rod. Never spring them over the shaft or sleeve.

If ring shows cracks due to handling, install it anyway as these cracks will heal.

If packing has become hard and nonconformable without breaking, oxidation has taken place and the packing should not be used.

Packing should not be kept in stock longer than three months. It should be kept in a cool place, away from heat.

Plastic packings, due to plastic flow under pressure, may have a tendency to extrude out through the stuffing box bushing or between the gland follower and the rod if these clearances are not kept reasonably close. This may necessitate end rings of a less conformable packing such as the flexible semimetallic types.

Wire and Cable Recommendations for the Pulp and Paper Industry

TAPPI Data Sheet 157

(THIS DATA SHEET IS UNDER THE JURISDICTION OF THE ELECTRICAL ENGINEERING COMMITTEE)

The selection of cable should be based on: (1) the proper insulation, (2) type or method of installation, (3) over-all reliability of the power-distribution system, and (4) cost.

The tables show the recommended cable selection in terms of areas, exposure, voltage classes, and installation methods. All of these cable types have been proved in paper mill service and are commercially available from manufacturers.

The use of these tables and data must be tempered with practical realities, e.g., even though a specific area may be "dry," if the cable runs through a liquor, chemical, or wet area, the cable should be selected for the most adverse conditions.

It will be noted in the application tables that paper-insulated cable is not included. Although paper is an excellent cable insulation it requires extreme care in making proper terminations and splices. It is this termination problem—i.e., the lack of trained personnel to make joints properly—that has led American industry to avoid paper cable. This is in contrast to

Table I. Cable Recommendations—Key to Classes of Cable Designs for Various Installation Conditions

Cable type	*Cable description—general*
1	Heat and moisture-resistant rubber insulation with neoprene sheath
2	Polyvinyl chloride insulation (PVC)
3	Varnished cambric insulation, PVC jacket with interlocked armor[a]
4	Varnished cambric insulation, with lead sheath and neoprene or PVC hose jacket[b]
5	Ozone-resistant rubber[c]
6	Asbestos varnished cambric with lead sheath and hose jacket[d]
7	Mineral insulation
8	Manufacturers' recommendations

[a] The armor may be made of galvanized steel, bronze, or aluminum to be used as follows: galvanized steel—dry locations only, no chemical fumes; bronze—exposure to atmospheres containing liquors, chlorine, alkali; aluminum—exposure to sulphur compounds, moisture. For exposure to turpentine fumes an outer protective covering of polyvinyl chloride or neoprene over armor is recommended.

[b] Wherever varnished cambric lead is listed, paper-insulated lead-covered cable with proper hose jacket may also be used if competent cable splicers are available.

[c] For applications above 3000 v., shielding is required; below 3000 v. shielding is optional.

[d] For dry locations, lead sheath and hose jacket may be replaced by an asbestos braid.

Note: All cables to be manufactured in accordance with latest applicable PICEA Specs.

Table II. TAPPI Cable Recommendations—Nature of Installation Conditions and Cable Recommendations for Same

Area	Nature of exposure	Exposure index	Operating voltage	Method of wiring installation: Conduit or underground duct	Method of wiring installation: Aerial cable	Method of wiring installation: Open racks, trays, troughs
Acid-making plant	Moisture, acid	BC	Below 600	2 (1, 4)	2 (1,3)	3 (2, 1)
			Above 600	5 (4)	5 (3)	3 (5)
Bleach plant	Chlorine, sulphur steam	CE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Boiler room	Dry, heat	AD	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Causticizing	Lime, liquors, steam	CE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Chip preparation	Outdoor—wet	B	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
	Indoor—dry or wet	B	Above 600	5 (4)	5 (3)	3 (5)
Chlorine plant	Chlorine	C	Below 600	2 (1, 4)	2 (1, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Coating	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Control room	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Digester	Steam, liquors, turpentine	CE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	3 (3)	3 (5)
Evaporator (liquor)	Steam, liquors	CE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Filter room (fresh water)	Wet	B	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Finishing converting	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Grinder room	Wet	B	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Hemp cooking and washing	Wet, liquors, steam	BCE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Lime recovery and evaporators	Wet, caustic	BC	Below 600	2 (1, 4)	2 (1, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Machine room (paper)	Wet, steam	BE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Machine shop	Cutting fluids, oils	C	Below 600	2 (1, 4)	2 (1, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Office buildings	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Pulp decker, screen and washer	Wet, liquors, steam	BCE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Rag bleaching	Chlorine, steam	CE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Rag cooking and washing	Wet, steam liquors	BCE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Rag preparation	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Recovery boiler	Heat, liquors	CD	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Stock preparation	Wet	B	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Sulphur burner	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Turbine room	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	1 (2, 3)
			Above 600	5 (4)	5 (3)	3 (5)
Wastepaper cooking	Wet, steam	BE	Below 600	1 (4, 6)	1 (3)	3 (1, 6, 7)
			Above 600	5 (4)	5 (3)	3 (5)
Wastepaper cutting and storage	Dry	A	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Wet machine room (thickeners)	Wet	B	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Wood room	Wet	B	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)
Woodyard	Outdoor, wet	B	Below 600	1 (2, 4)	1 (2, 3)	3 (1, 2)
			Above 600	5 (4)	5 (3)	3 (5)

Note: Number not in parentheses is preferred construction per Table I. Numbers in parentheses are alternate permitted constructions.
Index Key: A, dry; B, wet; C, acid, caustic, liquors; D, high temperature; E, steam.

some Canadian mills who have the trained personnel and who have had good experience with paper-insulated cable.

If properly installed, paper-insulated-leaded cable can be used in the same areas, exposure conditions, and installation methods listed for varnish-cambric-leaded cable.

It is recommended that leaded cables have a hose jacket over the lead to prevent electrolysis or chemicals from damaging the lead.

It is recommended that the industry follow the specifications set forth in the IPECA Specifications.

D.C. APPLICATIONS

It is suggested that the same types of cables be used for d.c. applications as listed for a.c.; the evidence available regarding operating experience for d.c. service did not indicate that any special cables were necessary.

Tenth Engineering Conference
Rice Hotel, Houston, Texas
Nov. 7–9, 1955

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Empire State (Central District)

The Central District of the Empire State Section of TAPPI met at 7:00 p.m., April 1, 1955, at the University Club, Syracuse, N. Y., for its monthly dinner meeting. There were 73 present.

Chairman F. W. O'Neil called the meeting to order. A "Ladies Night" Committee made up of Earl Foster, chairman, Earll Church, and Bert Channer was appointed.

The nominating committee presented the following slate of officers for next year:

Durward B. Geffken, chairman
William H. Holl, vice-chairman
S. Earll Church, treasurer
Barbara H. Wortley, secretary

The above people were unanimously elected.

F. G. Sommerville made a brief announcement concerning the Empire State meeting at the Whiteface Inn in June. He also reminded those present of the approach of the Sixth Coating Conference.

Chairman O'Neil hoped that many would be able to attend the International Mechanical Pulping Conference at Poland Spring, Me., in September.

The meeting was then turned over to D. B. Geffken, vice-chairman, who introduced the main speaker, Harold C. Brill of the Pigments Department of E. I. du Pont de Nemours & Co., Inc. Mr. Brill's topic was "Recent Developments in Titanium Research."

Many new and interesting uses for titanium compounds in the paper industry were discussed. Excellent fire-resistant treatment for cellulosic materials may be secured with a water-soluble titanium and antimony complex. The titanium esters can be used as adhesion promoters for laminations of paper with aluminum foil, polyethylene, vinyls, cellophane and other dissimilar materials. Paints capable of withstanding 500°C. and corrosion resistant can be prepared by using a titanium organic in the formulas. Triethanolamine titanate can be used as a dispersing agent. Titanium dioxide dispersions prepared with this chemical have excellent resistance to flocculation by alum. This property is of value for size press coatings.

Mr. Brill performed many experiments illustrating the above properties of titanium organics.

(Mrs.) Barbara H. Wortley, *Secretary*

Recent Developments in Titanium Research

Harold C. Brill

Any discussion of titanium or titanium chemicals may be covered under the headings of the relatively few general uses which these chemicals have found. At the moment, the dioxide of titanium is the most important commercially, but the metal is making rapid strides and might develop to a similar level of importance. The dioxide is the most efficient and most powerful whitening and opacifying pigment per unit weight used today. It is used in paper, paint, floor covering, rubber, plastics, synthetic fibers, ceramic enamels, etc., because of properties resulting from its high refractive index.

The ductile metal has become available in the past decade and at the present time most of the uses are limited to military applications. However, the metal has one of the highest strength per unit weight ratios of any known metal and this coupled with the excellent corrosion resistance give promise of making it ideal for certain peacetime uses. The paper industry may wish to make use of the high corrosion resistance in various bleaching operations such as chlorine dioxide or hypochlorite. Others may wish to take advantage of its acknowledged superiority in corrosion resistance to sodium chloride or nitric acid. The military are using it at the present time principally in aircraft construction to increase strength or reduce weight.

Most of the audience present tonight has read about or used titanium as a pigment or a metal. However, it is unlikely that many of you have heard that an excellent fire-resistant treatment for cellulosic materials may be secured with a water-soluble titanium and antimony complex. The resulting treatment is so firmly bound to the cellulose that the treated product may be subjected to numerous washings without serious loss of the fire-resistant properties.

During the past decade, we have all witnessed and come in contact with a new group of chemicals called silicones. Most papermakers have used them in the mill as excellent anti-foaming and release agents. At home, we have all encountered them as an ingredient of car polishes. These unusual metal-organic compounds are also used in making special rubbers and resins for high temperature paints. Titanium falls directly below silicon in the periodic table and will also form organic compounds. However, silicones are characterized by a silicon to carbon bond whereas the titanium organic compounds described in this paper are linked through a Ti—O—C bond. We shall devote most of the evening to a discussion of the properties of these new and interesting chemicals. In order that we may follow the gradual discovery and development of titanium organics, we shall start with the discovery of the element titanium and list the various major developments in titanium chemistry in the order of their appearance.

H. C. Brill, E. I. du Pont de Nemours & Co., Inc.; F. W. O'Neil, College of Forestry, State University of New York; Barbara H. Wortley, Solvay Process Div., Allied Chemical & Dye Corp.; F. G. Sommerville, Armstrong Cork Co.; D. B. Geffkin, Oswego Falls Corp.; and S. E. Church, College of Forestry

Harold C. Brill, E. I. du Pont de Nemours & Co., Inc., Newport, Del.

1790 The element titanium was discovered by a Reverend William Gregor in Great Britain (*1*).

1869 The first recorded use of titanium as a paint pigment by Ryland in England. A black, ground, ilmenite ore was put in a paint vehicle.

1906 M. A. Hunter produced pure titanium metal experimentally from the reaction of metallic sodium with titanium tetrachloride (*2*).

1918 The first commercial production in the United States of a white extended titanium dioxide pigment by the Titanium Pigment Co. (*3*). This company was later purchased by the National Lead Co.

1924 Bischoff and Adkins prepare tetra ethyl titanate and tetra methyl titanate (*4*).

1926 Pure anatase titanium dioxide pigment was being produced commercially in Europe using the sulphuric acid process and the Blumenfeld hydrolysis (*5*).

1928 Commercial Pigments Co. initiated production of pure anatase titanium dioxide in the United States (*5*). The process was based on sulphuric acid and used the Blumenfeld hydrolysis method. This method of anatase production is used by the present-day suppliers. Du Pont acquired this company in 1931.

1937 Du Pont marketed the first alumina-treated anatase titanium dioxide pigment for improving the light stability of paints.

1940 J. Nelles (*6*) prepared titanium alcoholates and phenolates by the reaction:

$$TiCl_4 + 4ROH + 4NH_3 = Ti(OR)_4 + 4NH_4Cl$$

1940 Kroll, a citizen of Luxemborg, developed a method of producing ductile titanium metal by reducing titanium tetrachloride with magnesium. Most of the metal produced today is made by these reactants.

1941 Du Pont began the first commercial production in the United States of pure rutile titanium dioxide. Du Pont and Titanium Pigment Co. marketed a calcium sulphate extended rutile pigment this same year.

1941–1942 Du Pont marketed chalk resistant rutile pigments for exterior colored paints.

1946 U. S. Bureau of Mines begins pilot plant operation for producing ductile titanium metal by the Kroll process in 100-lb. batches (*7*).

1947 Kraitzer, McTaggart, and Winter of Australia announce the formulation of heat resistant paints using aluminum flake with a tetra butyl titanate binder (*8*).

1948 Du Pont began the first commercial production of ductile titanium metal.

1949 Du Pont began commercial production of a titanium-antimony complex for treating cellulose fiber to make it fire resistant.

1950 Du Pont placed a number of titanium organic compounds on sale.

The rapid growth of the titanium metal industry in the United States in the past 10 years was based on the same chemical reaction used by Kroll:

$$TiCl_4 + 2Mg = Ti + 2MgCl_2$$

This process requires the use of large amounts of anhydrous titanium tetrachloride. Previously, this chemical had been used by the military to a limited extent for smoke screens and no large scale plant was available for manufacture. It is now prepared:

$$2TiO\cdot FeO \pm 7Cl_2 + 4C = 2TiCl_4 + 2FeCl_3 + 2CO_2 + 2CO$$

Ilmenite

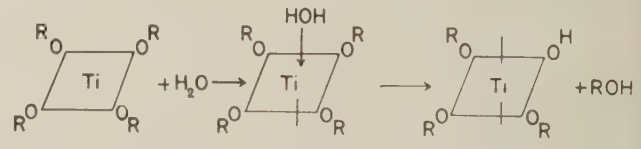
The titanium tetrachloride must be of excellent purity to insure the preparation of ductile titanium metal. Once a large scale supply of this chemical was available, it was a natural step to investigate the commercial possibilities of the organic derivatives of titanium. Interest was also increased by the work of the Australians Kraitzer, McTaggart, and Winter (*8*) in formulating heat resistant paints with tetra butyl titanate. There are three main classes of titanium organics which we will discuss this evening. They are titanium esters, titanium chelates, and titanium acylates. The first two classes will be of the greatest interest to the papermaker.

Titanium Esters

These chemicals vary from very fluid liquids such as tetra ethyl titanate and tetra isopropyl titanate to waxy solids such as tetra stearyl titanate. The one exception to this rule is tetra methyl titanate which is a hard brittle solid and apparently associated to a considerable extent. Titanium esters are distinguished by high chemical reactivity, particularly with water and hydroxy compounds. They differ from similar silicon organics in this respect since the latter require a catalyst before hydrolysis is initiated. The titanium esters hydrolyze readily and polymers of the isopropyl and butyl esters can be prepared in various stages of polymerization from thin liquids to pasty solids.

Chemical Properties

Hydrolysis. The esters of titanium hydrolyze rapidly on exposure to water or moist air. Titanium has a valence of four and a maximum coordination number of six. The mechanism is believed to involve the formation of an intermediate complex between the ester and water. The reactions are shown in Table I. The hydroxy ester cannot be isolated



since it immediately reacts to give dimer. The hydrolysis

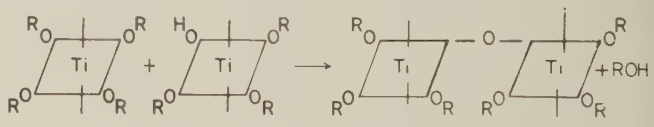


Table I. Physical Properties[a]

	TPT	*TBT*	*TOT*	*TST*
Appearance	Colorless liquid	Colorless liquid	Lt. yellow liquid	Waxy solid
Molecular weight (theory)	284	340	564	1124
Melting point, °C.	20	<−40	<−25	64
Boiling point, °C.				
1.0 mm.	58	120	194 (0.25 mm.)	...
10.0 mm.	116	206	....	...
100 mm.	175	...	....	...
760 mm.	232	...	....	...
Heat of vaporization, kcal./M.	10.2	9.8	....	...
Density, 25°C.	0.9550	0.9951	1.071	...
Viscosity, 25°C., cp.	2.29	72.03	147.9	...
Solubility in 100 parts:				
Water	Decomposes	Decomposes	Decomposes	Decomposes
Ethanol	α	α	α	Approx. 1
Hexane	α	α	α	Approx. 1
Benzene	α	α	α	Approx. 30
Carbon tetrachloride	α	α	α	Approx. 50

[a] The code letters used are as follows: TPT—tetra isopropyl titanate; TBT—tetra *n*-butyl titanate; TOT—tetra 2-ethyl hexyl titanate; TST—tetra stearyl titanate.

proceeds stepwise as shown in the following reaction:

$$x(RO)_3TiOTi(OR)_3 + xH_2O \rightarrow 1(—Ti(OR)_2O—)_{2x} + 2xROH$$

and continues as follows:

$$(—Ti(OR)_2O—)_x + xH_2O \rightarrow xTiO_2 + 2xROH$$

The end result, if carefully done, is a clear amorphous film of titanium dioxide.

The rate of hydrolysis varies with the size of the alkyl group. Tetra isopropyl titanate (TPT) and tetra butyl titanate (TBT) hydrolyze instantly on contact with water. As the alkyl group increases in size, however, the rate of hydrolysis decreases until it is fairly slow for tetra stearyl titanate (TST).

Alcoholysis and Ester Exchange. Titanium esters undergo alcoholysis with alcohols rapidly at room temperature and without a catalyst.

$$Ti(OR)_4 + 4R'OH \rightleftarrows Ti(OR')_4 + 4ROH$$

The production of higher esters or mixed esters is usually very easily carried out by mixing TPT with a stoichiometric quantity of the alcohol and distilling off isopropanol.

Titanium esters react with organic esters according to the equation:

$$Ti(OR)_4 + 4R'CO_2R'' \rightleftarrows Ti(OR'')_4 + 4R'CO_2R$$

This reaction also runs very smoothly and can be carried to completion by distilling off the lower boiling material.

Ester Exchange Catalysts. Ester exchange reactions are effectively catalyzed by titanium esters.

$$R''CO_2R' + ROH \overset{Ti(OR)_4}{\rightleftharpoons} R''CO_2R + R'OH$$

$$R'CO_2R + R'''CO_2R'' \overset{Ti(OR)_4}{\rightleftharpoons} R'CO_2R'' + R'''CO_2R$$

Catalysis by titanium esters in such reactions is quite general. Being inert in most systems titanium esters are especially useful with polymerizable materials such as methacrylates which are attacked or polymerized by standard ester exchange catalysts. Only catalytic amounts of titanium esters are required, usually from 0.1 to 5%.

Aldol Condensation Catalysts. Titanium esters are catalysts in aldol condensation reactions. Examples of reactions catalyzed by TPT are as follows:

Reactant	*Product*
Acetone	Triacetone dialcohol
Cyclohexanone	Cyclohexylidine cyclohexanone
	Dicyclohexylidine cyclohexanone
Benzaldehyde	Dibenzal acetone

Meerwein-Ponndorf Reactions. Titanium esters enter into Meerwein-Ponndorf oxidation-reduction reactions. A typical example of this reaction is the reaction of TPT with benzaldehyde to produce benzyl titanate and acetone.

$$4C_6H_5CHO + Ti(O—C_3H_7)_4 \rightarrow Ti(OCH_2C_6H_5)_4 + 4(CH_3)_2CO$$

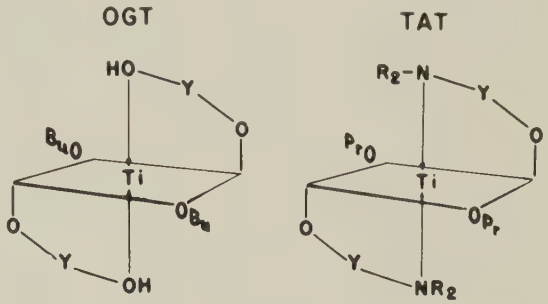
TITANIUM CHELATES

This class of compounds differs from the esters in respect to their stability to moisture. The chelates are much more resistant to hydrolysis and considerably less reactive. Some of the compounds in this class are soluble in water and form stable solutions. A number of potential uses for these water-soluble compounds may interest the papermakers. They gel and reduce the water sensitivity of polyvinyl alcohol, polyvinyl acetate, starch, and other hydroxy compounds.

Structure

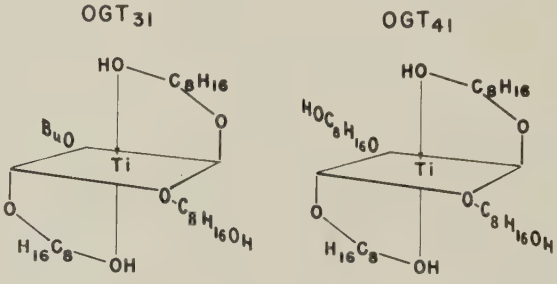
Titanium has a valence of four and a maximum coordination number of six. Therefore, it is possible to have, in addition to the four primary valence bonds, two secondary bonds formed by the acceptance of electrons from an atom capable of donating them. Oxygen and nitrogen atoms are electron donors and can form complexes with titanium.

If, through the formation of such bonds, a cyclic structure is produced, the compounds are called chelates. These can be shown symbolically in the following way, where Y represents the octylene glycol or triethanol amine groups, Bu represents the butyl group, and Pr represents the isopropyl group.



Each arrow in these formulas indicates a dative (secondary) bond. In the above formulas two moles of chelating compound (glycol or alkanol amine) are indicated. These are the stoichiometric quantities necessary to satisfy the maximum coordination number (6) of titanium.

Of course, it is possible to add more than two moles of chelating compound per titanium, the additional moles merely replacing the two alkoxy groups. Thus OGT-31 and OGT-41 may be represented by the following formulas:



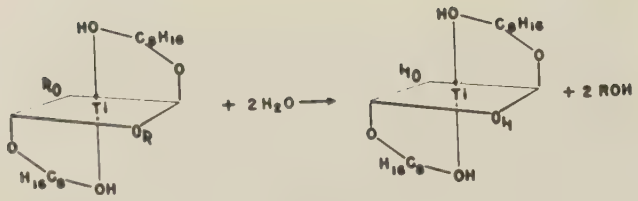
Neither octylene glycol titanate (prepared from 2-ethyl hexanediol-1,3) nor triethanol amine titanate are distinct compounds. They are not distillable nor crystallizable. They appear to be partially polymerized.

The polyhydroxy organic groups in both cases apparently do not form cyclic structures exclusively, and to a limited extent appear to bridge between the titanium atoms to give some degree of polymerization.

Although the chelated titanium esters are not as chemically inert as chelates of many other metals, they are much less reactive than the simple titanium esters. The properties and reactions of the simple titanium esters were described previously.

Hydrolysis

Octylene Glycol Titanate. Chelated titanium esters are much more stable to water than are the simple titanium esters. Octylene glycol titanate will hydrolyze to a limited extent at room temperature, but this hydrolysis does not proceed to the point where precipitation of titanium occurs. The hydrolysis can be represented by the following equation. The hydrolyzed product is called "washed OGT" and is very soluble in organic solvents.



Triethanol Amine Titanate and Its Salts. Triethanol amine titanate is soluble in water but will hydrolyze and become insoluble on standing several hours. TAT forms very alkaline solutions in water, and this probably causes the hydrolysis. If the solutions are neutralized, they become stable. Even if only enough acid to react with half of the amine is added, the stability of water solutions is greatly increased. Either inorganic acids, such as phosphoric and carbonic acids, or organic acids, such as acetic, lauric, stearic, oleic, or linoleic acids can be used.

Ester Exchange

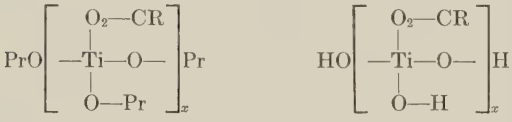
Chelated titanium esters do not exhibit the very rapid ester exchange which is typical of the simple titanium esters. If heated, however, lower boiling alcohols can be removed and polymers produced.

The reaction can be represented by the equation:

$$(RO)_2Ti(\text{—}OYOH)_2 \xrightarrow{\Delta} \left[\begin{array}{c} I \\ O \\ Y \\ O \\ I \\ \text{—}Ti\text{—}OYO\text{—} \end{array}\right] + 2ROH$$

TITANIUM ACYLATES

This class of compound has the following general formulas:



These chemicals are readily soluble in organic solvents and are excellent surface active agents. They are insoluble or decomposed by water and their stability to moisture is somewhere between the esters and the chelates. The compounds are polymeric but their high solubility in hydrocarbon solvents indicates that the degree of polymerization is not high. They break into titanium hydrate compounds and organic acids upon hydrolysis. We have not found any uses for these chemicals in the paper industry as yet, and for this reason we shall conclude our discussion on their properties.

TITANIUM ORGANICS USES

Titanium Esters

Adhesion promoters—the modern paper industry is undergoing vast changes in respect to the end uses of its products. The packaging industry is using paper in ways that were unheard of 10 years ago. Laminations of paper with aluminum foil, polyethylene, vinyls, polyester film ("Mylar"), cellophane, and other dissimilar materials are common today. The food packaging end of this field is growing by leaps and bounds. The mating of a hydrophilic material, such as paper, with hydrophobic materials, such as polyethylene, polyester film ("Mylar"), and vinyl plastics, has caused the papermaker and the converter many problems. One of these problems that has arisen is adhesion. Possibly, it might better be described as the lack of adhesion. We believe that the use of titanium esters as adhesion promoters for various materials offers a new, inexpensive, and useful approach that will solve a wide variety of adhesion troubles.

An adhesion promoter may be defined as a sandwich coat that permits two normally nonadherent surfaces to adhere. It is not an adhesive, but is used to supplement and improve the adhesion of these materials.

An adhesion promoter consists of:

1. A titanium ester; namely, tetra isopropyl titanate for adherent purposes.
2. A dry solvent for dilution and ease of application.
3. An organic additive:
   (a) To permit the successful deposition of an adherent film during high humidity periods; it might be called a hydrolysis suppressor. It may also improve adhesion between the top coat and the dried ester film and thus perform a dual function.
   (b) To speed up the ester hydrolysis after adhesion promoter film is deposited from the solvent. It might be called a hydrolysis accelerator. Unless speed of cure is required, this additive is not essential.

Only thin films of the adhesion promoters give adherent coatings. They are usually applied from 2 to 10% solutions in organic solvents.

The ester must hydrolyze *in situ* to secure adhesion. If hydrolysis occurs while it is still suspended in the solvent, a nonadherent, chalky film results.

Titanium ester films will adhere to some degree to practically every surface with a few polar groupings. Only tetrafluoroethylene ("Teflon") and polyethylene films have given essentially no adhesion when the ester film is applied to them. However, the ester film may be applied to other substrata and polyethylene bonded to the surface of the dried adhesion promoter.

Excellent adhesion is realized with most top coat materials

Table II. Physical Properties of Titanium Chelates

Compound	Molar proportions: Chel.	Cpd.[a]	Ti	Solvent	Appearance	Solubility in: H_2O	EtOH	Hydrocarbons
Titanium lactate	2	1	..	None	Solid	Sol.	Sol.[c]	Insol.
Titanium acetyl acetonate	2	1	..	Isopropanol 25%	Liquid	Sol.	Sol.	Sol.
Triethanol amine titanate TAT-21	2	1	..	Isopropanol 20.5%	Liquid	[b]	Sol.	Insol.
Octylene glycol titanates								
OGT-21	2	1	..	Butanol 24%	Solid	Insol.	Sol.	V. sol.
OGT-2.21	2.2	1	..	Butanol 25%	Tacky solid	Insol.	Sol.	V. sol.
OGT-31	3	1	..	Butanol 28%	Liquid	Insol.	Sol.	V. sol.
OGT-41	4	1	..	Butanol 31%	Liquid	Insol.	Sol.	V. sol.
OGT-21 (washed)	2	1	..	Cyclohexane 43%	Solid	Insol.	Sol.	V. sol.
OGT-2.21 (washed)	2.2	1	..	Cyclohexane 42%	Tacky solid	Insol.	Sol.	V. sol.
Triethanol amine titanate-*n*-oleate								
TAT-O-211	2	1	1	Isopropanol 14%	Liquid	Sol.	Sol.	Sl. sol.
TAT-O-212	2	1	2	Isopropanol 11%	Liquid	Sol.	Sol.	Sol.
Triethanol amine titanate-*n*-stearate								
TAT-S-211	2	1	1	Isopropanol 14%	Liquid	Sol.	Sol.	Sl. sol.
Triethanol amine titanate-*n*-linseed acids salt								
TAT-L-211	2	1	1	Isopropanol 14%	Liquid	Sol.	Sol.	Sl. sol.

[a] Chelating compound, i.e., octylene glycol (2-ethylhexanediol-1,3) or triethanol amine.
[b] Hydrolyzes on standing 24 hr.
[c] Soluble in glycols.

if the properly hydrolyzed titanium ester film is modified correctly. This can be accomplished by incorporating a suitable and compatible additive to bridge the ester film to the top coat.

Most adhesion promoter formulations containing titanium organic compounds require the use of organic solvents. However, several titanium compounds are now available for use in water solutions.

Adhesion promoters may be formulated to solve a wide variety of adhesion problems and will vary widely in the degree of adhesion secured. Just as paints vary considerably in quality, depending upon the skill of the formulator, so will adhesion promoters.

It is impossible in the limited time available to discuss all the possible uses of adhesion promoters for the paper industry. However, we shall discuss and give formulations for the adhesion of polyethylene to paper, glassine, aluminum foil, polyester film ("Mylar"), or cellophane. The greatest use and interest in adhesion promoters has been for this use. For most purposes, a 2% solution of tetra isopropyl titanate with an additive is placed in a hydrocarbon solvent and the paper or aluminum foil immersed, sprayed, or roll coated with the solution. The solvent is evaporated on heated cams or in drying ovens, and the ester allowed to hydrolyze by heating or steaming. The latter is the most rapid but the installation may be varied depending upon the machine speed. After this hydrolysis or cure, the paper will be covered with a dry, adherent, nonsticky, almost invisible coating which is stable to moisture and other solvents. The paper may be used at once or stored in rolls for many months until needed. It may be used by the manufacturer or sold to converters.

Present-day practice of laminating polyethylene to paper is based upon the use of high temperature polyethylene extrusion at 500 to 600°F., bringing the paper web in contact with the extruded film and passing the combination through a pair of chilled wringer rolls. Adhesion is aided by the surface oxidation of the plastic at the high extrusion temperature. Adhesion is frequently bad on smooth surfaced, heavily calendered papers or coated ones. The polyethylene film must be thick enough to cover paper irregularity or wicking will result. Overlap heat seals cannot be made with this type of product. Both the paper and the polyethylene deteriorate from the high temperatures required.

When the paper to be laminated is first treated with a titanium ester adhesion promoter, smooth, highly calendered papers, coated or uncoated, may be laminated to polyethylene, either from the cold film or from hot, freshly extruded plastic. Extrusion temperatures may be lowered to the minimum required by adequate extrusion practices, or machine speed increased. The physical strength of both the paper and the plastic are retained and the acetylenelike odor of oxidized polyethylene eliminated. If the paper is treated on both sides with the adhesion promoter, overlap heat seals of plastic to the paper are possible.

Formula 1 is suggested for thick porous papers where transparency is not a problem and overlap seals are desired at minimum temperatures. Formula 2 is generally preferred for extrusion on aluminum foil, cellophane, polyester film ("Mylar"), (also paper), and other places where a transparent laminate is desired and lamination temperatures to 140°C. are available. The latter formula is also more convenient to prepare.

Polyethylene Adhesion Promoter

Formula 1

Adhesion Promoter Stock Solution—20% Solids

	% by weight	*100-Gal. basis* *Lb.*	*Gal.*
Tetra isopropyl titanate	13.3	97.70	12.29
Polyethylene ("Alathon") 10	6.7	49.22	6.43
Xylol (dry)	80	587.67	81.28
	100	734.59	100.00

Adhesion Promoter—2% Solids

	100-gal. basis *Lb.*	*Gal.*
20% stock solution	72.42	9.86
Xylol (dry)	651.75	90.14
	724.17	100.00

Formula 2

2% Solution TPT (Tetra Isopropyl Titanate)
TST (Tetra Stearyl Titanate)

	% by weight
TPT	1.33
TST	0.67
Hexane (dry)	98.00
	100.00

Polymerization Catalysts for Silicones. A number of papers are being treated with various forms of silicone resins. Glassine is often coated with a thin coat of one of these chemicals as an adhesive (anti-sticking agent) film. The treated glassine is used as a cover coat for various pressure sensitive tapes and decals. Frequently, trouble occurs in these applications with the adhesive migrating into the pressure sensitive adhesive and injuring the adhesion. The difficulty is caused by the incomplete curing or polymerization of the silicone at the low drying temperatures that glassine can withstand. A marked improvement in lowering the time and temperature of cure can be secured by blending 2 to 20% of tetra isopropyl titanate or tetra butyl titanate with the silicone. Care should be taken to use a dry solvent. The drying rate of many film forming oils and resins can be markedly increased by titanium ester addition. It is possible that certain impregnations which are now impossible on the paper machine may become feasible.

Heat Resistant Paint. There are many places in the paper industry where a paint capable of withstanding 500°C. might be of interest. Kilns, smoke stacks, and heads of drier drums need a corrosion resistant paint as well as the improved appearance of a paint that will stand high temperatures. The formulas used in this study are as follows:

Aluminum Flake Top Coat

	Parts by weight
Aluminum paste (Reynolds 51)	48.3
Du Pont dibutyl titanate	31.0
Mineral spirits dry	21.6

White Top Coat

	Parts by weight
Titanium dioxide ("Ti-pure" R-510)	59.0
Du Pont dibutyl titanate	34.5
Mineral spirits	22.0

Zinc Dust-Corrosion Resistant Primer

	Parts by weight
Zn Dust (New Jersey Zinc Co. 22)	82.50
Mica (English Co. 325-mesh)	3.75
Bentone 34 (National Lead Co.)	4.50
Du Pont dibutyl titanate*	34.50
Mineral spirits dry	43.88

The above materials were used in our formulation work. It is assumed that similar materials of other suppliers will work satisfactorily.

Titanium Chelates

Titanium Lactate (Ti-Lac). Titanium lactate is a water soluble chelate with some unique properties for gelatinizing and insolubilizing water-soluble hydroxy compounds such as polyvinyl alcohol, starch, methyl cellulose, sodium carboxymethyl cellulose, glycerine, and various glycols. A stable solution of the lactate may be prepared at 50% solids and will have a pH of approximately 1.0 to 1.5. If neutralized with caustic, titanium hydrate is deposited. The lactate is a fair dispersing agent for titanium dioxide and fluid slurries

* Polymerized tetra butyl titanate.

may be prepared at 50% solids. The resulting slurry particles are positively charged.

If the water solutions of the lactate are allowed to stand overnight, refluxed, or boiled for 1 hr., this chemical may be used to trigger the setup of polyvinyl alcohol solutions and some polyvinyl acetate emulsions. A 4% solution of high viscosity polyvinyl alcohol will gel *in situ* if heated to 80°C. in the presence of 20% (based on dry PVA solids) titanium lactate. This gelation phenomenon is markedly affected by the concentration of the reactants. Thus 5% titanium lactate will gel a 10% solution of the alcohol. As little as 2% of the lactate has been observed to reduce absorption of 2% solutions of starch or polyvinyl alcohol into porous paper. A marked improvement in the water resistance of the resulting film is secured by the addition of an equivalent amount of hexamethylenetetramine with the titanium lactate solution. Gelation of starch *in situ* on heating is not effected by Ti-Lac but Ti-Lac, starch and polyvinyl alcohol may be gelled on the addition of either ammonia or caustic. The lactate may be used in the presence of melamine and urea formaldehyde resins since it is an excellent catalyst for setting these resins.

Titanium lactate is also soluble in various glycols. It dissolves readily in hexylene glycol (2 methyl-2-4-pentanediol) and may be used to gel or restrict the loss of various polyhydroxy or amine containing plasticizers for paper, cellophane, or glassine.

Triethanolamine Titanate (TAT). This chemical is soluble in water and alcohol. Solutions in water are very alkaline and stable for approximately 24 hr. If the solutions are neutralized with acid to approximately 7 pH, they are stable indefinitely. The addition of caustic to the water solutions will precipitate titanium hydrate. TAT will gel starch or polyvinyl alcohol solutions upon addition at room temperature. Immediate gelation is prevented if the TAT solution is neutralized with acid. Some insolubilization as well as plasticization occurs from this reaction.

Dispersions of titanium dioxide at 50% solids are readily prepared with 0.5% of TAT on the dry pigment. The dispersions prepared with this chemical have excellent resistance to flocculation by alum. This property is of value for size press coatings in the paper industry. Many size presses are operated with a high percentage of overflow and return to insure an even coating. The solution leaches alum from the sheet and a gradual buildup occurs. After a few cycles of the solution, the alum concentration is sufficiently high to cause flocculation of the pigment with a streaking of the coating. TAT may be of help in solving this problem.

Titanium Acetyl Acetonate. This liquid chelate is soluble in both organic solvents and in water. It was primarily designed for triggering reactions in organic solvents by heating. However, the water solution will gel starch and other hydroxy containing water-soluble adhesives. The principal difference between this material and titanium lactate or triethanolamine titanate is the organic portion. When used to gel or water insolubilize starch, the acetyl acetone is volatilized, but the other chelates retain the chelating chemical in the film.

SUMMARY

Titanium is the ninth most abundant element in the earth's crust. However, until recently it has been used primarily in the form of titanium dioxide as an opacifier and brightener of paint, paper, floor coverings, rubber, plastics, and ceramics. During the past decade, the ductile metal production has expanded from the laboratory to an annual production measured in the thousands of tons. The remarkable strength and corrosion resistance of this metal may soon place the usage of this form of titanium ahead of the dioxide. The papermaker may find usage for the excellent corrosion resistance of this metal in some of his plant operations.

Recently, titanium has been made available to the papermaker in the form of organic derivatives of the element. Although production is limited to a pilot plant stage, sufficient of the chemicals are available for most plant usage as well as research sampling. The investigator for the paper industry is urged to examine these interesting chemicals and develop new uses.

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New England

The New England Section of TAPPI met at 4:00 p.m. on April 1, 1955, at the Hotel Bond, Hartford, Conn. Approximately 70 people attended.

F. S. Klein, chairman, Byron Weston Co., Dalton, Mass., and G. L. Benson, vice-chairman, St. Regis Paper Co., East Pepperell, Mass., presided.

G. L. Benson, St. Regis Paper Co.; H. J. Perry, Lockport Felt Co.; F. S. Klein, Byron Weston Co.; and Robert Graham, Graham Corp.

The speakers for the technical portion of the program were: Henry J. Perry, formerly director of the Waste Paper Utilization Council, New York City, and Robert Graham, president, Graham Corp., Boston, Mass.

The main topic of both of the above papers was "waste-

Group at the New England Section meeting

C. L. Reese, Westfield River Paper Co.; H. J. Perry, Lockport Felt Co.; F. S. Klein, Byron Weston Co.; Robert Graham, Graham Corp.; Miss Ann M. Brown, Hercules Powder Co.; and G. L. Benson, St. Regis Paper Co.

Members of the Lake States Section observing the operation of a beta-gage basis weight recorder on no. 11 paper machine

paper." The handling, economics, etc. of the wastepaper industry was very ably presented by these gentlemen.

Mr. Perry stressed quality of wastepaper and the segregation and identification of troublesome materials frequently encountered in the waste paper sold to paper and paperboard mills.

Mr. Graham illustrated that in many ways the wastepaper collector was actually an employee or agent of the consuming mill in that the costs, cleanliness, availability, and ultimate price were covered by the supply and demand dictated by the paper and paperboard mills. It was also explained that the main product which waste paper dealers had to sell is man hours since the quality of the ultimate product produced by the waste paper collector is a function of labor.

Also, the maximum prices which the wastepaper dealer can charge for his products are limited by the availability and the price of virgin pulp.

Ralph Kumler, director of the Waste Paper Utilization Council, was also in attendance.

The next meeting of the New England Section of TAPPI will be its annual meeting to be held on June 3 and 4, 1955, at the Oceanside Hotel, Magnolia, Mass. Technical papers will be presented at this June meeting by Cap Howell, professor of Paper Technology, Chemical Engineering Dept., University of Maine, and former engineering manager, general plant manager, and member of the board of directors of the Scott Paper Co. Mr. Howell's subject will be "The Establishment of a Technical Control Program in the Paper Mill."

The above will be a discussion of how the technical control program can be sold to the personnel in the mill who, ultimately, will make it work.

A second speaker for this program will be Horace Lee, Professor of Paper Technology, Lowell Technological Institute, Lowell, Mass. Mr. Lee will discuss and demonstrate several phases of microscopy and exemplify the advantages to be gained from the proper use of a microscope in the paper mill laboratory.

R. W. Ramsdell, *Secretary-Treasurer*

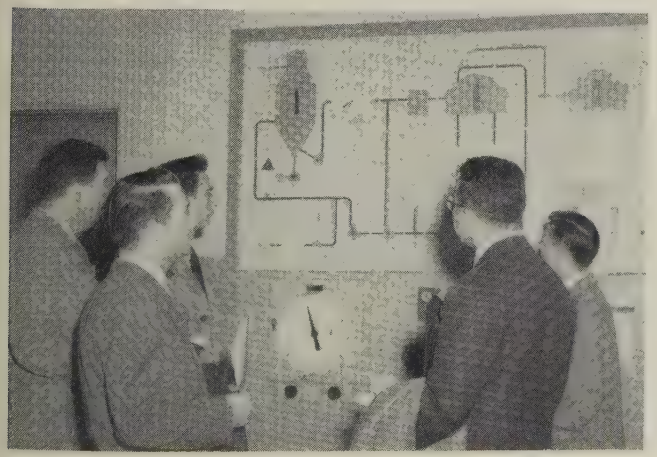
Lake States

The March meeting of the Lake States Section consisted of an afternoon visit to Thilmany Pulp and Paper, dinner at the Elks Club, and an evening talk by E. Jennings of the Thilmany Pulp & Paper Co. The meeting was well attended with approximately 200 members and guests. The evening talk consisted largely of a review of the history of the Thilmany Pulp & Paper Co. by Mr. Jennings.

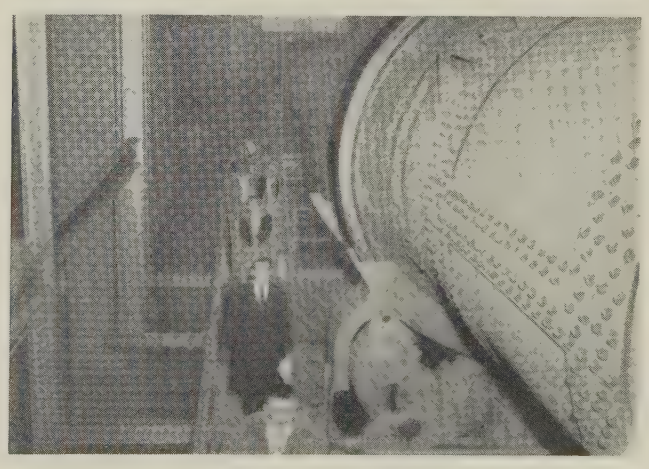
John W. Bard, *Secretary*

Empire State (Northern District)

The March meeting of the Northern District, Empire State Section of TAPPI, was held on March 10, at the Hotel Woodruff in Watertown. The program was a panel discussion, "Basis Weight and Caliper Control." J. Wayne Morrow,



The color-graphic instrument panel used in conjunction with the brown stock washing system at Thilmany Pulp & Paper Co.



Group walking past the new 8 by 150 ft. lime kiln recently installed at Thilmany

Newton Falls Paper Mill, was the moderator and panel members were: George Nelson, Bird Machine Co.; William Bishop, Electric Eye Equipment Co.; Arthur Landsman, Fischer and Porter; and John Thoman, Industrial Nucleonics Corp. Approximately 65 members were present and enjoyed the discussion and the question and answer period which followed.

(Miss) Elizabeth L. Case, *Secretary*

The Role of Flow Control in Basis Weight and Caliper Control

A. L. Landesman

"I can make good paper and hold to basis weight specifications without any fancy instruments." Several old-timers among papermakers have thrown this fact at me and I'm sure also at other instrument peddlers. It is a fact because I'm equally certain that these papermaking artists could make good their boasts.

Having made that admission, I still wish to proceed to show the need for modern instrumentation for control of paper basis weight and caliper. Perhaps the need exists merely because the skill of the old-timers is not being handed down to us of the younger generations. However, I prefer to look at it from a different viewpoint. Increasingly severe competition in the industry coupled with ever-increasing rates of production has brought larger mills with larger and more complex machinery. More rigid product specifications have and will continue to be imposed upon the production people. Neither mill management nor the ultimate user of the paper or paperboard will be satisfied with a basis weight fluctuation of $\pm 5\%$ if it is possible to hold $\pm 3\%$. Mill management will not be satisfied with the present rate of product rejected due to off-weight if it is possible to reduce that rate economically.

These then are the principal reasons for replacing human know-how and its inherent inconstancies with precision instruments to control basis weight and caliper. Of course, a man's brain must tell the instrument what to do, but once the instrument has been set, it will continue to hold that control point without variation until the brain decides a change is required. Another reason for instrument control of basis weight represents money in the company's treasury. One paper mill here in New York has stated that installation of a stock flow rate controller has enabled them to constantly "shade down" and hold to the lower limit of the weight specifications. Since this mill sells its product by area, that is, by the ream, the weight saving is a direct dollar saving which at this particular installation has amounted to several thousands of dollars per month.

All of the factors which affect control of basis weight can be condensed to four principal variables. They are: (1) consistency of the stock delivered to the headbox, (2) flow rate of stock to the machine, (3) machine speed, and (4) retention of furnish on the wire.

Retention depends on a combination of conditions, and I had better leave a detailed analysis to more experienced papermakers. Suffice it to say that for a particular grade of paper, constant retention depends largely upon constant composition and treatment of the furnish.

Stock preparation systems vary from mill to mill. The control of stock preparation also varies tremendously from one location to another. As many of you already know, the company I represent enjoys the reputation of being the source for application know-how and the instrumentation for stock preparation systems. Because our business was built largely on a base of experience in flow measurement and control, it follows that the flow variable plays a large role in basis weight control.

The instrumentation for stock preparation ranges from a simple indicating flowmeter for adding a small stream of rosin size up to complete control systems for blending continuously several additives with several types of slushed pulp. We tend to remember the big ones, so I'm reminded of a complete system for control of stock preparation we recently supplied to a mill in Pennsylvania. This instrumentation has been the means of converting from an outdated batch process to a modern continuous stock preparation system which assures a uniform furnish for five paper machines. Briefly, five complete flow measurement and ratio control units automatically blend three types of slush pulp. Chemical additives are under instrument flow control. Stock treatment is uniform also since the flow to each of six refiners is also regulated by the flow control equipment.

There is no need to delve into details of other instrument systems. Permit me to re-emphasize the importance of controlled stock preparation—it will affect retention of furnish on the wire—a major factor in control of basis weight and caliper.

Machine speed is satisfactorily measured and controlled by existing tachometers and other electrical instruments. Most of us will agree that during normal running times speed of the paper machine fluctuates to only a slight degree. However, it is during those warm-up periods and during a change of speed due to a change of paper grade that adjustments for machine speed are desirable. The adjustment required is a change in the volume of stock fed to the machine.

This brings us to another relationship between basis weight control and flow rate control. With retention, machine speed, and other minor variables being negligible during normal runs, the control of basis weight depends entirely upon delivering a constant net weight of fiber to the wire. Control of both volumetric flow rate and of consistency are required to deliver a constant weight rate of flow. Consistency control coupled with manual control of flow is not sufficient. The pressure upstream of manual flow regulating valves can fluctuate with changes of level in stock chests, with wear on pump impellers, etc. It is necessary to eliminate the effects of such pressure variations by employing some other form of flow rate control.

Either one of two methods of stock flow control is commonly employed in paper mills. The oldest method is the use of an open headbox containing a fixed weir which the stock overflows to maintain constant head on an adjustable stuff gate by which the rate to the machine is controlled. Although it does control stock flow, this equipment has disadvantages which will be described. The alternative is to use a flow control system composed of a flow rate meter, automatic control instrument, and pneumatic control valve. The advantages of the alternative are the disadvantages of the flow box. They are:

1. The flowmeter is installed directly in the stock piping and results in a closed stock system. The open overflow of the flow box frequently results in entrainment of air which can interfere with sheet formation. This fact is affirmed by the development of the pressurized machine headbox, one of the benefits of which has been the elimination of another point of air absorption.

2. Since the overflow is at atmospheric pressure, it requires large return piping to minimize pressure loss during the long run to the machine chest. This piping is expensive; the horsepower required to recirculate the overflow stock also represent wasted money.

3. The recording control instrument provides a permanent record of flow rate, useful as a guide to both the operator and supervision. One can have visual proof that this variable is being held constant. The instrument also provides a fine calibration scale with numbers which permit easily resetting to a desired control point. Inexpensive but accurate control stations can be used to permit setting the flow controller from either wet or dry end of the machine. Coincidentally, a mill

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here in Watertown has installed a control system for this purpose. Although bugs still exist in the installation at the present time, I'm confident that the system will operate as planned and will provide the benefits expected by the mill management.

4. Because they require gravity flow, stuff boxes are frequently located where they are inconvenient to reach or where the atmosphere is uncomfortable for personnel. This disadvantage is particularly emphasized on start-ups and grade changes; modern instruments save many steps and much stair-climbing.

5. A modern automatic flow controller will permit coming to weight faster than with a manually operated stuff gate. A good automatic controller responds instantly to a deviation from the control point.

The last factor in basis weight control is consistency control. It is obvious that control of consistency is required in order to deliver a constant weight of fiber to the paper machine. I will leave the discussion of consistency to another speaker, but I will comment that there is a great field for a more accurate consistency regulator. Even when operating to the limits claimed by us manufacturers, these devices are the source of greatest error in a basis weight control system. Since the errors involved in all the variables are additive, we can say that the weight or thickness control can be no better than the control of stock consistency.

I hope that some of you have been saying to yourselves, "If you want to control basis weight, why don't you measure the variable you want to control?" It is true, technically, that control systems, whenever possible, should be based on measurement of the variable to be controlled. In this case, a basis weight controller should continuously measure basis weight.

It is largely because of consistency variations that thickness controllers and also basis weight controllers of the beta ray type have found wide application. Undoubtedly these instruments are capable of reducing caliper and basis weight fluctuations, and they have proved their value. However, these devices cannot control paper basis weight by themselves —they need help. Whether the weight sensing device be located at wet or dry end of the machine, an appreciable time lag exists between measurement and corrective action of stuff-gate or flow control valve. If other variables such as flow rate, consistency, and moisture content were uncontrolled, the long time lag would cause the basis weight controller to cycle continuously out of control.

It has been said that thickness and weight controllers would not be necessary if a more accurate consistency regulator were available for use with modern flow control systems correlated with machine speed. However, I prefer to believe that a basis weight control system is a cooperative venture. Its function cannot be fulfilled by a single instrument. It must be accomplished by employing a cascaded system combining all the best control devices available.

The Part of Consistency Regulation in Basis Weight and Caliper Control

George Nelson

In recent years there have been many advances in automatic controls applied to paper machines to give the best product with the least variation in its properties.

One of the most important advances is the automatic control of the basis weight and/or caliper of the sheet as it is being made on the paper machine. The advantages of such controllers are many and will no doubt be described by the other speakers.

This brief talk will be devoted mainly to the part played by the consistency regulator, either acting as an adjunct to another controller, or performing its own special function as a separate and distinct unit in the mill flow system.

George Nelson, Bird Machine Co., East Walpole, Mass.

A control system may be compared to a ride in an automobile. We all know that any car, regardless of its make or price, will give a much smoother ride on a modern superhighway than on a back country road. We also know, that even though roads are being made better each year, so are the spring suspensions of automobiles being constantly improved upon in each new model. This combination doubly insures a continuous improvement in car riding comfort.

Today's papermaking machine can manufacture a product which is as superior in uniformity over the paper made years ago, as the ride in a new car on modern highways compares with a similar ride taken some years ago.

This improvement in product accuracy is due, in no small measure, to the adoption of and the continued improvement in control systems. Three important variables affecting product uniformity are: sheet weight or caliper, volumetric rate of stock flow, and stock consistency. The caliper or weight controller applies the final correction to the entire control system; but for best results it needs proper flow and consistency control just as much as a brand new automobile requires a first-class road for the smoothest possible ride.

The consistency regulator is deemed to be a necessary part of any system involving the control of basis weight or caliper. The usual location of the consistency regulator for this type of service is after the machine chest, as close as possible to the paper machine. The regulated consistency may be at some value between about $1^1/_2$ and 3%. If a plunger-type stock pump is used, the entire stock flow is sent to an indicator box containing a mixing compartment. The dilution water is added here, and the mixture flows to the main part of the box containing a sensing-element. The indicator box may be equipped with a stuff gate to control the flow of regulated stock leaving the box, or a separate flow controller may be employed.

With a centrifugal pump there are several choices. A sample flow of about 50 g.p.m. can be taken from the pump discharge line, fed to a small indicator box, then back to the machine chest or to the pump suction piping. The dilution water is added at the pump suction and is thoroughly mixed in the centrifugal pump. Flow control must be made independently.

An alternate method sends the total stock flow to the indicator box, with the dilution being added at the pump suction. A stuff gate can be used on the indicator box to regulate the outgoing stock flow.

In all proposals where the dilution water is to be added at the pump suction, particular attention must be paid to the time lag of the system. The stock should flow from the point of dilution to the indicator box in the shortest possible time, preferably less than 15 sec. If the time lag is too great, an indicator box with mixing compartment should be used. With the dilution water added at the box, the time lag is under 5 sec., and accurate control is assured.

Consistency control is also used in conjunction with other types of controllers. For example, a blending system requires a combination of flow and consistency control. Omitting the consistency regulator here is the same as doing only half the job.

The consistency regulator can also aid materially the effectiveness of other types of controllers. One specific example may be of interest:

A New York State paper mill, making a high grade food packaging board, recently installed a moisture controller on the driers of the paper machine. Shortly thereafter a consistency regulator was tried out on the filler stock just before the flat screens ahead of the cylinder vats. This regulator so helped the moisture control system that consistency regulators were also installed on the liner and underliner stock. The mill reported a noticeable increase in moisture uniformity and a saving of approximately 5% in steam consumption.

Just as the consistency regulator helps to smooth the road for other controllers, so can the way be paved to provide the

optimum operating conditions for the consistency regulator and thus insure its top-notch performance. Mill conditions which influence consistency control are the following:

1. Well-mixed unregulated stock. The great majority of consistency regulators receive stock pumped from a chest. Even though the consistency of stock entering this chest may fluctuate badly, proper chest agitation will smooth out the sharp irregularities and permit the regulator to very accurately control the outflow from this chest. In locations where a chest is not available, such as in a gravity flow from a thickener, uniformity of flow through the thickener will greatly increase the accuracy of consistency control.

2. Adequate incoming consistency. The consistency regulator can control consistency only by adding a variable amount of water to dilute the incoming stock to a predetermined set point of consistency. If the incoming stock is lighter than this set point, it is obvious that the dilution valve will remain closed and the stock will go on in the system uncorrected. This condition is easily detected from an inspection of the two-pen recording chart of the regulator. It may be corrected either by raising the incoming consistency or by lowering the set point of consistency.

3. Uniform dilution water pressure. The consistency regulator should be called upon to vary its dilution valve opening only to compensate for consistency variations. Additional valve changes made necessary from fluctuations in water pressure may over-work the regulator and impair its accuracy. A slow drift in dilution water pressure will not be harmful to the regulator, but sharp pressure fluctuations due to sudden water demands elsewhere can raise havoc. It may be necessary in some instances to provide an independent dilution water supply.

Of greatest importance in any consistency regulator installation is the proper choice of components. Most manufacturers can supply consistency regulators of various forms and sizes depending upon the stock flow and the consistency. In all cases the dilution valve must be sized properly. Both the consistency sensing device and the point of dilution must be properly located in the mill flow system.

After recognizing that all these variables exist, it is evident that each consistency regulator installation should be tailor-made for the individual application. Here close cooperation between the mill and the manufacturer will pay dividends. The mill should supply accurate data and pertinent information for a proposed installation. Then it becomes the duty of the manufacturer, using these data and information, along with his own experience and know-how, to properly engineer the installation and furnish the correct equipment.

Ohio Section Educational Committee meeting: John Clouse, chairman, Oxford Miami Paper Co.; K. L. Hackley and H. R. Joiner, Champion Paper & Fibre Corp.; R. B. Deininger, Sall Mountain Co.; W. B. Csellak, Gardner Board & Carton Co.; and W. C. Martin, Moraine Paper Co. Not present: H. A. Smith, Mead Corp.; W. Petrich, Aetna Paper Co.; W. Larson, Champion Paper & Fibre Co.; L. Moore, Black Clawson Co.; and V. M. Showalter, West Carrollton Public School

Ohio

The fifth annual meeting of the Ohio Section of TAPPI was held Jan. 11, 1954 at the Manchester Hotel in Middletown, Ohio. One hundred fifty-five members of the Ohio Section were present to hear Alfred H. Nadelman of Western Michigan College, Department of Pulp and Paper, discuss "Stock Preparation."

William Larson, Champion Paper & Fibre Corp., introducing the speaker

A. H. Nadelman, Western Michigan College, speaker

Chairman Harold Joiner, Champion Paper & Fibre Co., Hamilton, Ohio, conducted a short business meeting, after which he introduced William Larson, also of Champion Paper & Fibre Co., the member of the program committee who arranged the meeting.

Mr. Larson introduced Mr. Nadelman, who brought out in his talk the results of several experiments that have been conducted recently at Western Michigan College in connection with "stock preparation."

All those present found Mr. Nadelman's talk very informative, especially since it dealt with unusual aspects of a difficult subject.

E. W. Petrich,
Recording Secretary

Some Aspects of Stock Preparation

A. H. Nadelman

In a discussion of stock preparation it is essential that we define our field and state exactly what we mean. For the purpose of this discussion, we should like to restrict stock preparation to that treatment which must be given to fibrous raw materials if we are to utilize them at maximum efficiency in the papermaking process. In tonight's discussion, at least, we would prefer to restrict the choice of fibrous raw materials to cellulosic fibers, freed from plant tissue by mechanical or chemical means and suspended in water. "Utilization at maximum efficiency," we should like to leave in general terms since efficient usage is dictated to a large degree by the specific end-use requirement for the paper manufactured and by economic consideration.

Figure 1 may look like a picture of a power cable with successive layers of wrapped insulation cut back from the wire at the core, but it is meant to represent the common plant fiber which we use in papermaking. The figure was chosen because it presents a stylized view of the fiber that is extremely useful in developing any concept of beating or stock preparation.

The thin outer layer in Fig. 1 represents the primary cell of a plant fiber. In this layer we find much of the lignin that may be associated with fiber. In fact, this cell wall may be

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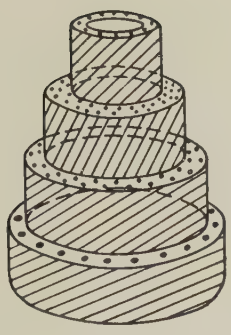

Fig. 1

regarded in many ways as being a sheath of nonreactive material which binds the tightly wrapped spirals of reactive cellulose in its grip. If we are to raise any sort of "fuzz" on the surface of the fiber, we must first remove this constrictive "girdle" of lignin, cellusans, and hemicelluloses.

This brief introduction is important in developing a basic premise in the problem of stock preparation. It permits us to consider the objectives of stock preparation more clearly than would otherwise be possible. Our objectives in stock preparation actually vary widely with the specific paper product we intend to manufacture, but certain common factors are universal. Whatever our concept of the stock preparation may be, we want to accomplish it at the absolute minimum in cost that is consistent with the desired quality of the final product. In all cases, we want our fibers to be bonded to each other to some degree. We want a sheet of paper that holds together and does not disappear as a cloud of loose fibers blowing through the roof vents in our mill. We also want a suspension that will result in the desired formation on the wire of the paper machine, whether it be uniform or nonuniform. We seek, also, some level of several strength characteristics or combinations of characteristics and some general level of sheet density.

How do we obtain these objectives, and with what variable factors may we work?

We may select the raw material with which we begin the process. To cite an extreme, for certain highly specialized applications, we may pay nearly $1000 a ton for a special, fully bleached long-fibered hemp pulp. Such selectivity makes even the current rising trend on the pulp market seem somewhat pale, but is justified if an extreme in the ration of fiber length to fiber width is required. We may choose kraft pulps made from southern pines with their thickened fiber cell walls caused by a predominance of summerwood. We may also pay a premium of several dollars per ton to obtain northern kraft fibers grown in a region where springwood predominates and more thin-walled, flexible fibers may be found where an ultimate in strength development is desired.

These variables in raw materials are controllable only to the extent that we may economically specify a certain material because of intrinsic properties of color, strength, or ability to respond to certain types of stock preparation equipment and treatment.

With our stock preparation equipment, however, we have in our hands a means for adjusting and controlling certain variables in the fiber preparation process. We may do much, for instance, to control the average fiber length by reducing this average below that which is an intrinsic property of the fiber in process. Unfortunately, this variable is controllable only by reduction and I know of no commercial fiber stretching device on the market today.

We can do much to control wet fiber flexibility by bruising and abrading the fibers to rub off the primary cell wall which contains a high percentage of the stiffening chemicals in wood. This same process does much to create opportunities for internal bonding of the fibrillar structures of adjacent fibers which creates increased fiber cohesion.

In short, we can do two basic things with our stock preparation equipment: (1) we can cut fibers, (2) we can split or unravel the fibrous elements. Cutting of fibers is the factor most closely related to fiber length and has long been recognized as an objective of stock preparation. The other factor has also long been recognized, but under a variety of terms, many of them now in popular or scientific disrepute. The unravelling of fibers is probably the objective of that part of stock preparation which has been known variously as hydration and fibrillation. For the sake of our discussion, we shall refer to this property as fibrillation.

Figures 2, 3, 4, and 5 are taken from a paper presented by Schmut, *et al.* They show four physical characteristics as measured for sheets made from bleached, west coast kraft pulp at various stages in the stock preparation process, using a laboratory beater. Curves which are familiar to most of you are shown on the figures as "whole pulp." Plotted on the same axes are several other curves, each one for sheets made from fibers of a given average length, fractionated from the whole pulp at each of the levels of development in the stock preparation process. One thing is instantly apparent. At any given average length, a rapid change is made in the characteristic measured at a very early point in the beating process. Once this point has been reached, little or no continuing change is noted. The developments and changes in the curve for the whole pulp must, therefore, be due largely to a combination of shifts in average fiber length within the whole pulp, and to the effect of fines produced and washed out of the various fractions isolated for investigation. As a side note, we might point out another factor involved. When one thinks of cutting a fiber, the first picture that comes to mind is one of placing a knife squarely on the midpoint of the fiber and producing two halves with substantially equal dimensions. This, however, is not the way our stock preparation processes operate. When cutting occurs it is almost equally likely that it will be done very near the ends of the fibers rather than at or near the exact middle of the fibers. In fact, with the production of only a small amount of cut fiber debris, it becomes much more difficult, on the average, to cut a fiber anywhere except near an end. Therefore, our cutting process is mainly one of making the longest fibers a little shorter while diminishing the shorter fibers to a kind of mush.

A consideration of these factors then shows how we may make some fairly simple moves which may result in more economical operation of our stock preparation equipment. We may institute the reorganization of our equipment to provide two or more primary systems so that fibers with inherently different qualities may be prepared separately to give each one the optimum treatment for its natural variables. This same technique of separate preparation may even be useful in some cases where pulp from one source may be separately prepared to give a blended ultimate effect in the final sheet. As an example of this, we might treat one portion of a pulp

William Larson, Champion Paper & Fibre Corp.; A. H. Nadelman, Western Michigan College; H. R. Joiner, Ohio Section chairman; W. H. Aiken, vice-chairman; E. H. Schriver, program chairman; and John Clouse, Education Committee chairman

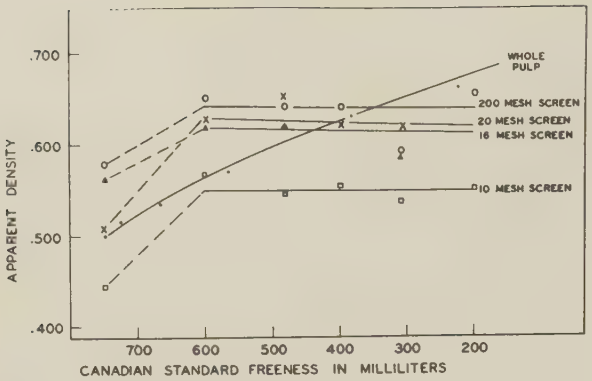

Fig. 2. Apparent densities of the various fractions

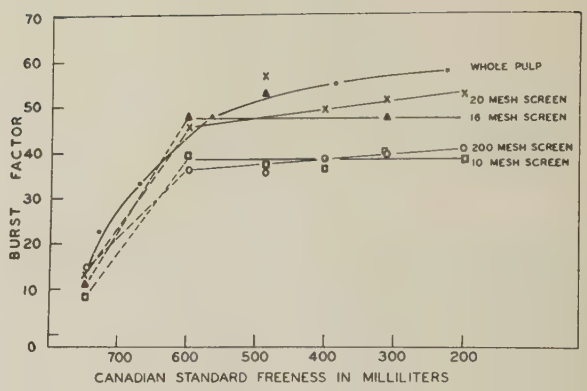

Fig. 4. Burst factors of the various fractions

with light mechanical action to give maximum length with a good opportunity for bonding, while the balance of the pulp might be treated to give a maximum in fibrillation with a high percentage of shortened fibers and much of the "mush" that was mentioned earlier. In this case the longer fibered portion might form the "skeleton" for the sheet while the second portion of the same pulp from a different refining system would serve to fill in the interstices between the skeletal fibers to increase sheet density and its attendant characteristics.

I have devoted most of this discussion of stock preparation from the viewpoint of the fiber. The discussion would hardly be complete if I were to avoid some mention of the mechanical equipment used in obtaining the objectives of stock preparation.

A logical start for this discussion goes back to the origins of papermaking when the Chinese prepared their fibrous stock by mashing it in a form of mortar and pestle. What is essentially this same technique persists today in only slightly modified form in the widely used European kollergang. The long discontinued stamping mill for stock as well as limited usage of rod mills and ball mills for refining are other offshoots of this technique. From a consideration of the approach, it may be seen that the bruising and abrading of fiber is the primary objective of this treatment and the adjustment of fiber length is almost a completely incidental item.

Next in development came the Hollander, named after its origin in the Netherlands. This piece of apparatus supplied the opportunity for production of the large volumes of stock that were required with the transition of papermaking from a hand process to a machine process. The principle of the beater is one of circulating fibers in a water suspension by sweeping bars across a stationary plate also equipped with bars. This principle has had various steps in its refinement and has taken various tangent and parallel directions.

One step in the development of the Hollander has been the use of an increasing percentage of its circumference or by the use of multiple bedplates. We might even say that the jordan is the continuation of this trend in that the entire circumference of the beater roll is utilized, by making it conical and surrounding it with a shell which takes the place of the bed plate. Further modification of this development may be seen in a variation of the angle of the conical portion. This variation, carried to the ultimate, produces a disk refiner.

Variations of the Hollander or jordan become even more complicated when we consider the possibility for varying the consistency at which stock is furnished to the machines as well as the variations in speed of operation, closeness of contact and pressure of flow to which the devices are subject. We may also vary the fittings of these pieces of equipment, using steel, bronze, or lava roll and shell construction to obtain various modifications in the basic action.

Two modifications of the base principles which are so drastic as to compose what is almost a new basic approach are the Curlator and the Alibe refiner. The Curlator is essentially a disk refiner which uses a gyratory motion instead of a high speed rotation. This results in a dewatering of the fibers in the area of action and in a perceptible curling of the fibers. The Alibe refiner is essentially a high consistency classifier and refiner operating as a cycling system to allow recirculation of a selective portion of the fiber, either long or short, to provide an accurately proportioned fibrous product.

We can hardly say that we believe that man's ingenuity has reached a limit, so we may safely say that we expect a continued variation of the principles described here as well as the probable development of one or more that are basically new and novel in their application to the problem of fiber treatment or stock preparation.

This thought leads us to the realm of conjecture in the field of stock preparation. Associated with the area of stock preparation, we have a long history of the use of starches, mannogalactans, and other hydrophyllic colloids in conjunction with mechanical equipment to improve the strength of sheets through the development of additional bonding and

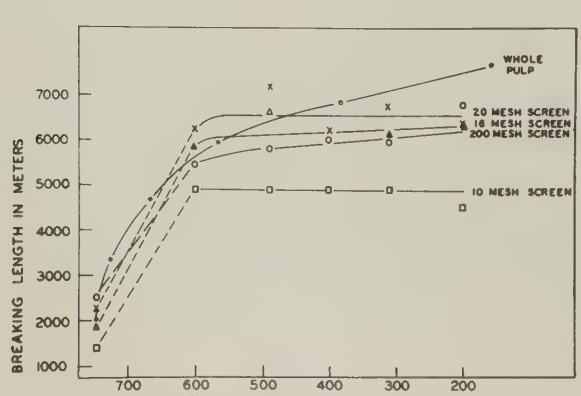

Fig. 3. Breaking lengths of the various fractions

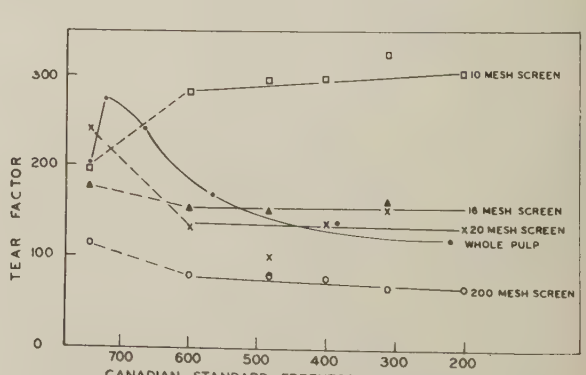

Fig. 5. Tear factors of the various fractions

through an improvement in the formation of sheets. It is probable that action in this field will not be neglected and that every effort will be expended in attempting to supply us with bonding from a barrel. While it is improbable that stock preparation will ever be measured by the gallon, it is probable that the use of hydrophyllic colloids and other chemical bonding agents will continue to be an important adjunct to mechanical stock preparation.

It is also possible, looking into our crystal ball, to see that some entirely new approaches will be involved in stock preparation. For one thing, variations in consistency may be carried to an extreme that will allow certain steps to be carried out in an air dry state, or at some spot intermediate between the consistencies now in common use and that extreme state. It is also possible that water will be intensively recycled about certain steps in preparation to provide no overall consistency change while allowing almost infinite dilution in certain restrictive areas.

Supersonics may yet be commercially important in the preparation of stock. It is possible to visualize a stock preparation system which would consist of a long pipe equipped with ceramic generators for supersonic energy. Automatic controls keyed to a central coded setting for a given grade of stock might react to small variations detected at the machine wire to adjust the energy generation of the supersonic sources. In a slush pulp operation, such a beater room would be entirely unmanned with no labor charge other than that due to maintenance of the system.

Also on a continuous pipe system, it is not inconceivable that selective enzymatic processes might be utilized for the continuous production of stock with a given set of characteristics. Here, control might be exercised by minutely varying the temperature of the stock as it passed through the pipe that would replace our expensive beater rooms. Control would also be exercised by quantity and nature of the enzyme used in the process. Fantastic? Yes. Impossible? No, we must wait for the future, and we must encourage the growth of ideas so that the fantastic and improbable today may become possible and economical tomorrow.

September Meeting

The following paper was presented at the meeting of the Ohio Section, Sept. 16, 1954.

Recent Investigations at the Institute of Paper Manufacturing at Darmstadt

Walter H. Brecht

May I begin with the assurance that I deeply appreciate the honor of being allowed to talk to you. It is, moreover, a great pleasure to me since I owe America very much. When I was young, I spent a full year at a famous American paper mill. The experience of this year enlarged my knowledge in my own field as well as in a general sense. During World War I and immediately after, we in Germany felt hopelessly isolated. Our industrial development had become stagnant, and we did not know anything of the development and progress in other countries. It was again in this country that I, as a guest of the United States, realized what has been achieved here to such an overwhelming extent and what a surprising standard of life had derived from it. Now, I am here for the third time and am given the opportunity to attend a symposium which will most probably reveal the latest knowledge gained in the physical-technical field of papermaking. Therefore, there are many reasons for my being obligated to the United States.

In 1955, it will be 50 years that the Institute of Paper Manufacturing at the University for Technology at Darmstadt was founded. Here, we are training engineers of papermaking and are being assisted in this task by other departments. It is a principle of our institute to combine teaching with research, so that both disciplines support and deepen each other. According to the nature of the Institute, we devote ourselves to applied research, the results of which will give the young engineers the intellectual tools to solve certain problems better and more competently. The single trends of research are of course, reflecting the tendencies of technical development. I will give you three examples of research work, the selection of which indicates rather clearly in which fields we try to achieve satisfying results with the comparatively small means of our disposal.

Example 1 shows the attempt to investigate a method of stock preparation that, coming from America, was successfully initiated with us after the war.

Example 2 deals with the design of an equipment to measure the full character of a paper quality, the judgment of which was only made individually until now. It is the formation which plays a great part especially with papers of high qualities.

The third example shows our efforts to find the cause of a very disagreeable characteristic through which some papers suffer a heavy loss of value. I am referring to the formation of cockles.

THE PULPING SPEED OF PULPS AND PAPERS DURING DISINTEGRATION

The pulpers belong to that group of machines which fundamentally changed the technique of papermaking after the war. Their specific power consumption depends on the time of pulping which is determined by the construction characteristics and the working conditions of the machine, but above all by the particular pulping quality of the stock. The most economical operating results will, without any doubt, only be achieved when the operating conditions are made variable and adjusted to the pulping quality of the stock. For this reason, it is necessary to know the pulping quality.

We have been developing a laboratory process to indicate clearly the pulping quality of pulps. We use a small device which, under exactly determined conditions, performs the pulping and a small flat screen which enables us to check at any moment the procedure of the state of the pulping.

The sample to be tested is cut into pieces of equal dimensions which are moistened with water before the treatment in the apparatus. The pulping is done with the apparatus, shown on the left of Fig. 1, in which a propeller of a special shape rotates at 1600 r.p.m. For each experiment, 40 grams of dry pulp are put into the pulper, at a consistency of 2.0% and an initial temperature of 15°C.

To determine the degree of pulping, the suspension is taken

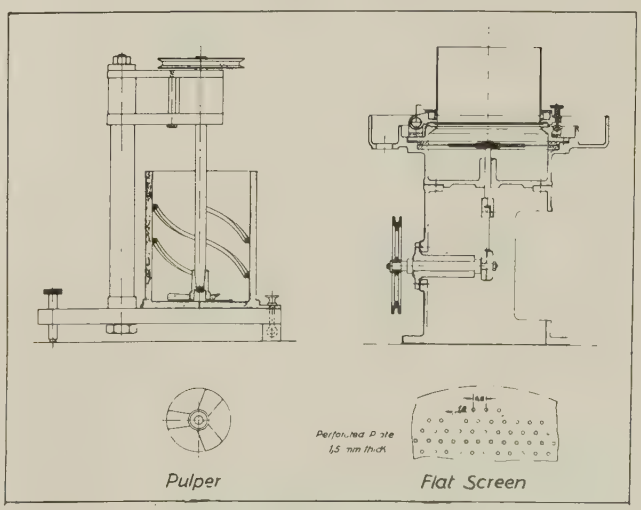

Fig. 1. Laboratory pulping apparatus

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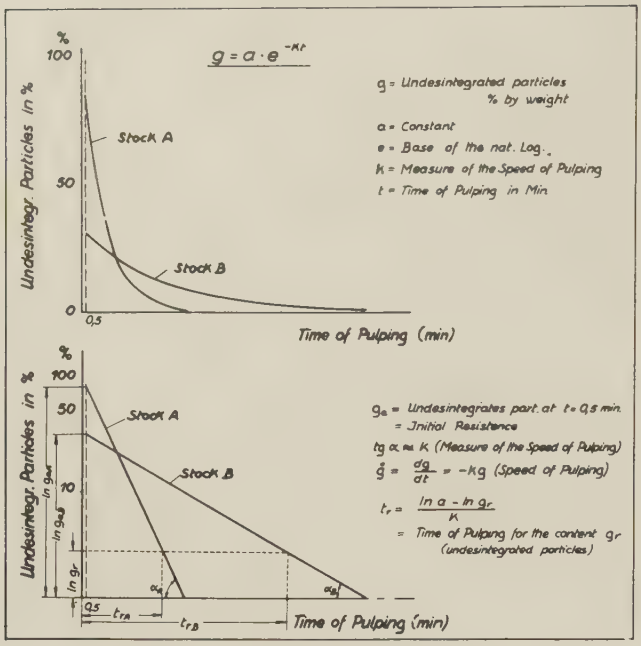
g = a · e^-Kt
g = Undesintegrated particles % by weight
a = Constant
e = Base of the nat. Log.
k = Measure of the Speed of Pulping
t = Time of Pulping in Min.
Undesintegr. Particles in %
Stock A
Stock B
Time of Pulping (min)
g0 = Undesintegrates part at t = 0,5 min. = Jnitial Resistence
tg α = K (Measure of the Speed of Pulping)
ġ = dg/dt = -kg (Speed of Pulping)
tr = (ln a - ln gr) / K
= Time of Pulpng for the content gr (undesintegrated particles)

Fig. 2. Typical pulping curves

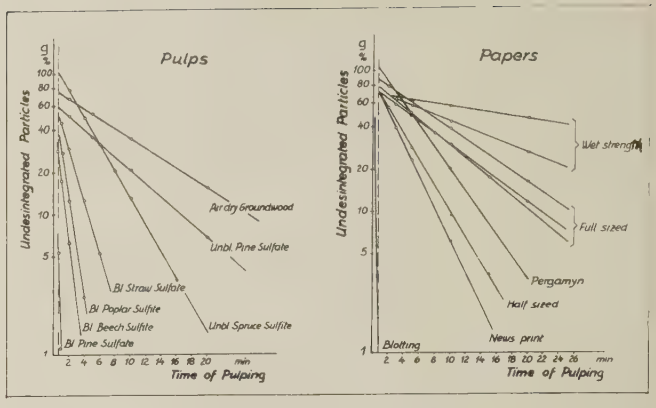

Fig. 3. Pulping curves for pulps and papers

out and separated into disintegrated and undisintegrated particles by the screening device shown on the right of Fig. 1. The suspension is directed into the cylindrical headpiece of this device. On a flat screen, the pulp receives a mild washing by water jets which come out of the borings of a water channel that surrounds the container. With the suction and pressure influence of a vibrating membrane, the suspension water together with the disintegrated particles goes through the screen.

After a certain time, the screen with undissociated particles left on it is taken out and the residue is indicated after being dried and weighed as "undisintegrated" particles in per cent of weight. The quantity used amounts to 2 grams (moisture free) at 0.5% consistency. A screen plate with a hole diameter of 1.5 mm., having a spacing of the holes of 6.8 mm., proved to be very good. Under the working conditions of the device it lets only disintegrated particles pass but no fiber bundles and keeps the undisintegrated particles cleanly washed, free from defibered material.

If the content of the suspension of the undisintegrated particles is plotted against the time of pulping, you get, according to the quality of the stock to be disintegrated, curves of the type shown in Fig. 2. With stock A, the disintegration begins slowly, but continues very rapidly. With stock B, it disintegrates very quickly at first, but the further diminishing of the undisintegrated particles takes a long time. The other curves lie in between these extreme types, but they obey an exponential function according to the formula in Fig. 2. Half-logarithmically drawn, they show the below indicated straight course, which is determined sufficiently by two points of intersection.*

The graph gives three factors.

The first consists of the quantity of undisintegrated particles determined after the first half minute. It shows the initial resistance. The second factor describes the speed of disintegration with the angle α. The higher it is the steeper will be the lines. The third factor is represented in the time of pulping, whether it be for nearly complete pulping, that is for the content of undisintegrated particles, $g = 0.1\%$, or for a certain remaining content of undisintegrated particles g_r. To determine it, you draw an abscissa parallel straight line through point $(g\tau)$ which shows the final content of undisintegrated particles, and project its section with the curves upon the abscissa.

When testing some pulps and papers, we obtained Fig. 3. In the case of short-fibered pulps, such as the hardwood and the usual straw pulps, the initial resistance proved to be small and furthermore, the pulping progressed very fast. The resistance of the long fibered, unbleached softwood pulps was essentially higher, and the whole process of pulping took a longer time. But glancing at the curve of the soft bleached softwood-sulphate pulps, we learn that the pulping is not due only to the fiber length but to the pulping and bleaching degree in connection with the other properties of the stock. Moist groundwood, which is not indicated on the figure, showed the same reaction as dried, short-fibered pulps. Air-dried groundwoods, however, especially if they are pressed, may differ from the rule by a very high resistance. In regard to papers the first part of the process, with the exception of the easily pulping blotting paper, is generally more than the pulps. The beating of the stock has already strengthened the fiber felt. Even almost unsized papers which disintegrate very rapidly during the entire process are resistant to a certain degree in the beginning. This is also true for newsprint, the resin-sizing according to the sizing degree determines the further processing. Surprisingly, glassine paper, produced from a very slow stock and very densely formed, has a high initial resistance but changes to a relatively fast pulping.

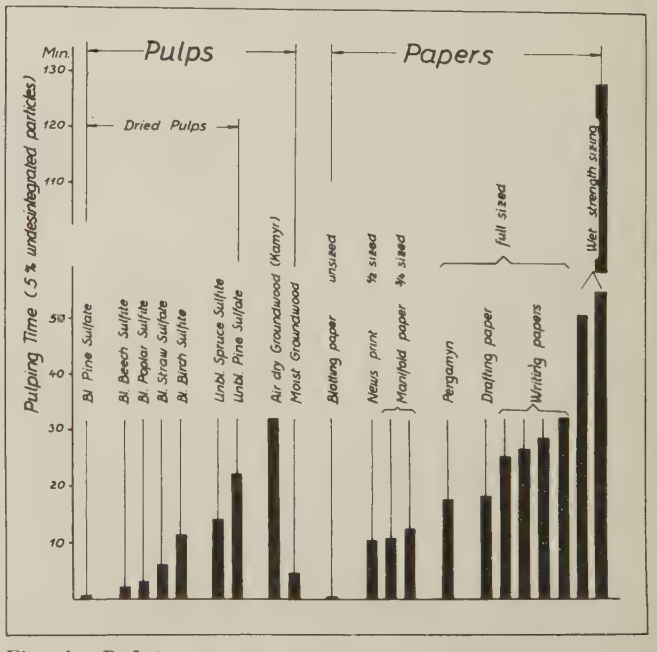

Fig. 4. Pulping time at g = 5% undisintegrated part

* The curves should start from 100% undisintegrated particles, because at the time of pulping of 0 minutes the stock should be unchanged. Some pulps show signs of a distinct decay during the first seconds of water wetting. It is not possible to measure during this period, not only because of the short time, but because the screening process works too inaccurately with the extremely high content of coarse undisintegrated particles. If therefore it is not possible to indicate what happens during the first phase of pulping (treatment) it must be assumed that the law found for the surveyable course of the curve does not possess the same validity for the first period.

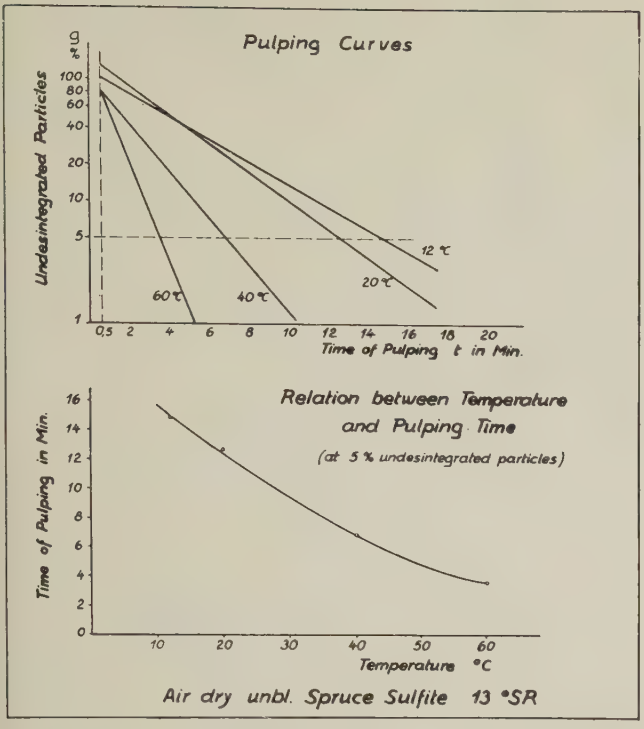

Fig. 5. Influence of temperature on pulping

While Fig. 3 contains the full pulping curves, Fig. 4 demonstrates with bar graphs the pulping time until only 5% of undissolved particles were left. It would have been of little use to extend the experiment to a still smaller percentage since, for reasons of power economics, the pulpers are operated until the remaining undisintegrated particles are 10 or 20%. There are rather remarkable differences between the pulping time of the single pulps and of the papers. With papers, the nature and degree of sizing decide the result; with pulps, the type of fiber and the content of lignin and accompanying substances.

Figure 5 shows the influence of the temperature on the pulping of an air-dry, unbleached, and unbeaten spruce sulphite pulp. As we expected, the curves prove that the initial resistance as well as the further pulping, speed is very much dependent on the temperature. At higher temperatures, the stock is pulped much more quickly than at the lower temperatures. The graph below shows above the temperature the pulping time needed till the remaining content of undisintegrated particles amounted to not more than 5%. In the beginning, the curve declines rather steeply, later on less steeply. The time gained by an increased temperature is therefore of greater consequence at the lower areas of temperature than at the higher ones.

MEASURING OF THE CLOUDINESS OF PAPERS

Every papermaker knows what is meant by cloudiness.

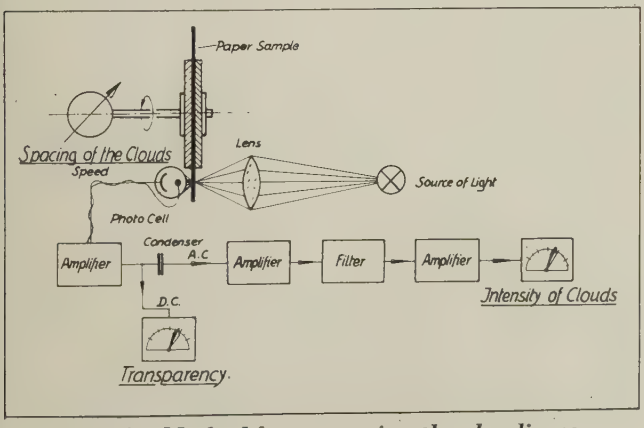

Fig. 6. Method for measuring the cloudiness

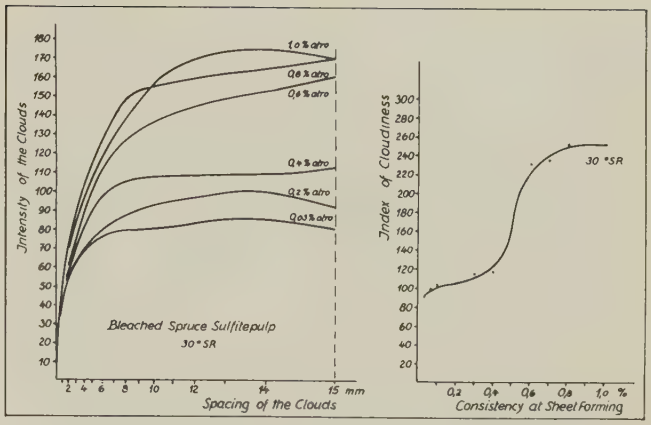

Fig. 7. Influence of consistency on cloudiness

It consists of the contrasts which you see when looking at the paper against the light. Nothing shows the workmanship of a papermaker better than his ability to avoid cloudiness. Quite apart from the aesthetic question, the good formation gained by the absence of cloudiness secures the technical quality of a paper in more than one regard. The advantage of an independent measure is therefore quite obvious.

Measuring devices have been developed, but these devices usually give only one value which therefore does not conform with the visual judgment for the real character of cloudiness is shown by two criterions: (1) by the intensity of the clouds, that is by their density and size; (2) by their spacing. A description of our measuring procedure has been published some time ago.† Therefore, it may be permitted to give just a short explanation in order to continue with some applied examples.

Figure 6 demonstrates the scheme of our method. A disk of the paper to be examined is clamped between two smaller metal disks. Driven by a motor, the unobscured part passes the slit of an optical feeling system. The current created in the photocell is thereby composed of a direct current, corresponding to the average transparency of the paper and of an alternating current, derived from the fluctuations and thus indicating the cloudiness. The direct current is separated after the first amplifier and indicated in a direct current instrument. After another amplification, the alternating current passes an adjustable electrical filter, serving to extract the single frequencies from the mixture of alternating current. Each frequency corresponds to a certain space of the clouds which is determined by the respective adjustment of the filter. After another amplification of the separated frequency, its intensity is shown by a current measuring device. It corresponds to the intensity of the clouds.

To obtain a simpler system, we use a filter adjusted to a constant frequency and instead of changing the filter adjustment, we alter the number of revolutions of the paper disk step by step. A certain space corresponds to each number of revolutions and for this space, the intensity of the cloudiness is recognized on the measuring device.

If you draw the different cloud spaces on the abscissa, and the corresponding cloud intensity on the ordinate of a diagram, you get a curve which is fundamental for the judgment of the cloudiness. With some practice, such a diagram takes about 1 to 2 min.

It was of course necessary to treat the indication of cloudiness of the device so that it corresponds to physiological judgment. Since big clouds strike the eye much more than small, densely spaced ones, we emphasize the influence of comparatively wide-spaced, large clouds by logarithmically distorting the abscissa of the clouding space. Moreover, the intensity of the clouds, read from the device, must be de-

† Brecht, W., and Wesp, A., "Die Messung der Wolkigkeit von Papierer," *Das Papier* 6, Heft 17/18 (Sept., 1952) und Heft 19/20 (Oct., 1952).

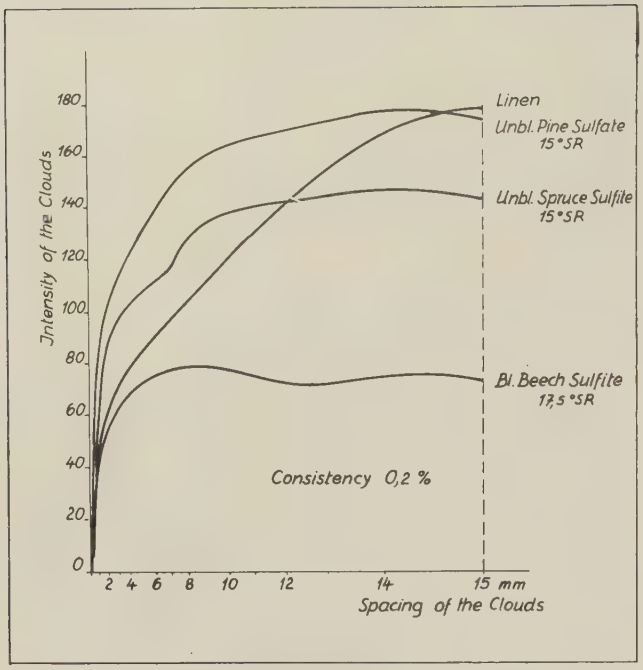

Fig. 8. Type of fiber and cloudiness

creased. At constant illumination, the eye will be irritated by the differences in the transparency of the papers, but this irritation is only logarithmically growing and not linearly. Therefore, the intensity value, indicated by the device, is not divided by the full transparency but by a logarithmic measure, and thus immediately read from the scale of the direct current instrument. Rather intensive studies showed that by this treatment the full agreement with the visual judgment is obtained.

By a simple numerical manipulation, we can also get an index of cloudiness which condenses the mentioned modified curve of cloudiness into a single value.

Influence of the Stock Concentration on Formation

Figure 7 demonstrates the results of studies which investigated the important influence exerted by the consistency at the beginning of the sheet formation. On the left the intensity lines above the cloud spaces are shown for different consistencies of a softwood pulp suspension. With a high consistency, these curves extend into the areas with large, wide-spaced clouds. These large, wide-spaced clouds disappear all the more perceptively with a decreasing stock density. The clouds become smaller and are moreover more regularly distributed. The whole connection is seen on the right of the figure where the index of cloudiness is recorded. With pulp

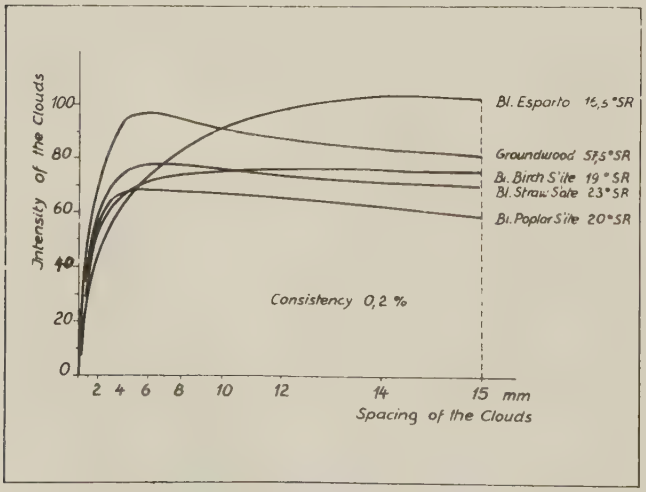

Fig. 9. Type of fiber and cloudiness, short-fibered pulps

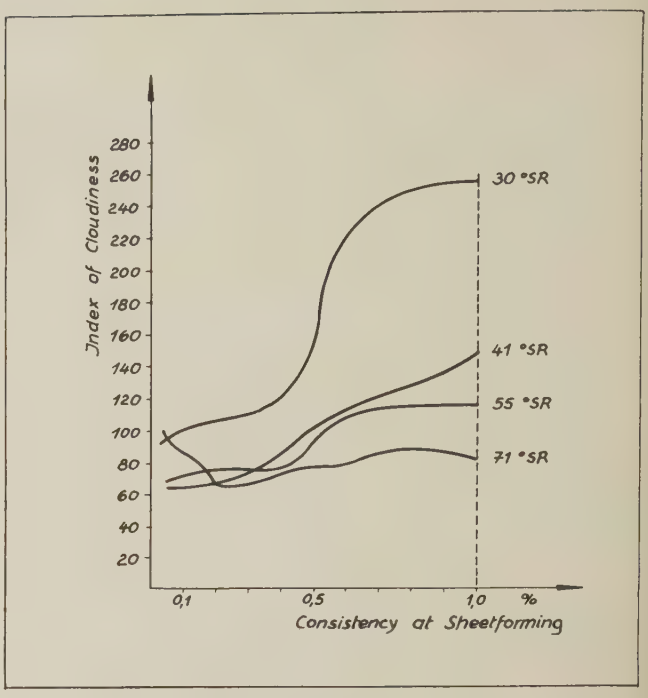

Fig. 10. Influence of beating and consistency on cloudiness

beaten to 30°S.-R. and with decreasing consistency, the diminishing of the cloudiness was specially evident in the area of the middle dilution.

Kinds of Pulps

Figures 8 and 9 exemplify the effect caused by the kinds of pulps. In the laboratory, we produced sheets from different stocks which did not undergo any beating. These sheets were made at a consistency of 0.2%.

Very intensive clouds with the biggest spaces were caused by the linen pulp. Also with pine sulphate pulp clouds were formed but smaller spaced. The spruce sulphite pulp gave a much better formation. The cloudiness was still less marked with short-fibered beech sulphite pulp. Figure 9 shows short-fibered material only. Straw sulphate pulp and, above all, poplar pulp proved to be very favorable. Also, groundwood yielded a relatively good formation because the most intensive clouds were smaller spaced.

Beating

When examining the sulphite pulp at different beating degrees as to the connection between consistency and cloudiness, we obtained the result represented in Fig. 10. It demonstrates for four different beating degrees the course of the index of cloudiness in its dependency on the consistency.

The influence of the consistency on the cloudiness decreases with increasing beating degree. With the beaten stock, the cloudiness over the whole range of the dilution is less marked than with the free stock.

The slightly rising curve of the stock of 71°S.-R. in the area of high dilution is the result of the diminished drainage speed on consequence of the high slowness. For this reason, the drainage time for the formation device in the laboratory was so long that the tendency to forming clouds was much stronger than in the case of less beaten stock.

The Wire Shake

As a further example in measuring the cloudiness, a special study shall be mentioned in which a certain paper machine was investigated as to how the shaking conditions influence the formation of the sheet.

Figure 11 shows the effect of wire shake on sheet in the center of the wire. 0/0 means operating without shaking.

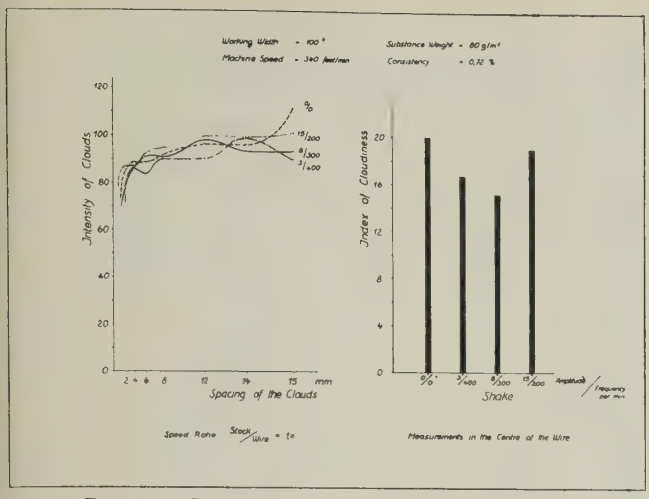
Working Width = 100"
Machine Speed = 340 feet/min
Substance Weight = 80 g/m²
Consistency = 0,12 %
Intensity of Clouds
Spacing of the Clouds
Index of Cloudiness
Shake
Speed Ratio Stock/Wire = 1:1
Measurements in the Centre of the Wire

Fig. 11. Cloudiness and shaking conditions

It yielded the highest cloud index. Intensive, wide-spaced clouds could be observed. These big clouds which are especially disagreeable to the eye were removed by the shaking. A shake of 15-mm. amplitude and a frequency of 200 per min. proved to be least effective. Here in the range of 0 to 13 mm., the cloudiness even surpassed that of the unshaken wire. Smaller amplitudes and increased frequency gave better results: 8-mm. amplitudes and a frequency of 300 per min. achieved the optimum. Here, the clouds were less intense and their average space smaller than with the other shaking conditions.

In the tests, demonstrated by Fig. 12, the speed ratio of the stock to the wire was changed, keeping all other factors constant. The conditions were most favorable when the speed of the suspension was the same as the wire speed. When the ratio was smaller than 1, the cloudiness increased, especially in the area of small spaces. A speed of the suspension which surpassed that of the wire proved exceedingly bad. The intensity of the clouds increased in the small as well as in the large cloud spaces.

The result of these shaking experiments must not be regarded as generally valid dependencies. They are but further examples which demonstrate the applicability of the cloudiness measuring method for research and manufacturing purposes. They are not meant as the attempt of a theoretical intrepretation.

COCKLING OF PAPER DURING DRYING

Generally, it is like this in technical life: first, a certain relation or a certain phenomenon is investigated and, then, a

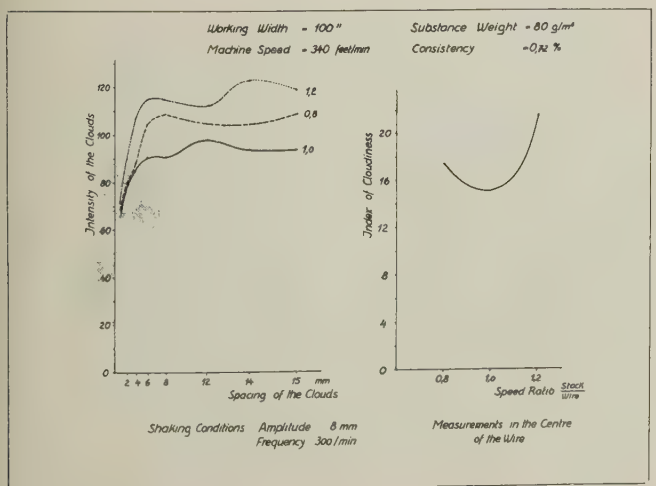
Working Width = 100"
Machine Speed = 340 feet/min
Substance Weight = 80 g/m²
Consistency = 0,12 %
Intensity of the Clouds
Spacing of the Clouds
Index of Cloudiness
Speed Ratio Stock/Wire
Shaking Conditions Amplitude 8 mm
Frequency 300/min
Measurements in the Centre of the Wire

Fig. 12. Cloudiness and speed ratio "stock and wire"

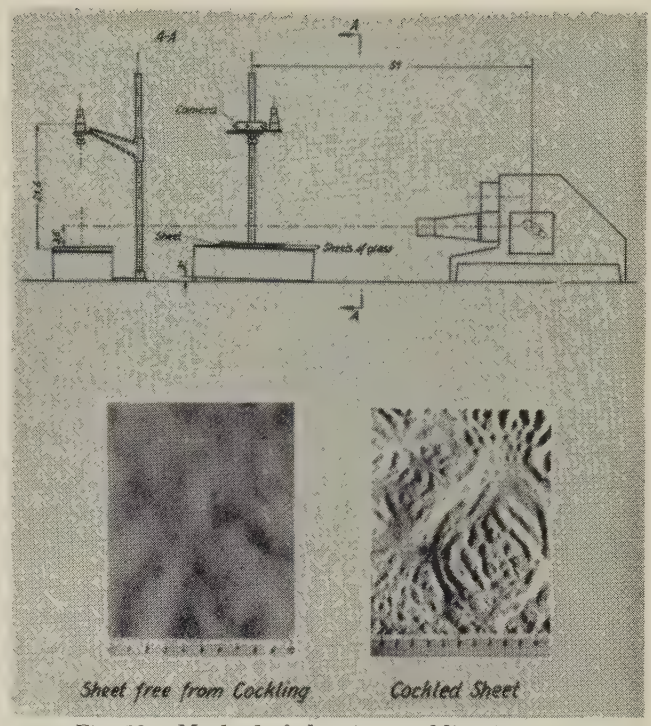

Fig. 13. Method of showing cockling in paper

theory as to their causes is worked out. It is just the other way round with the cockling of paper. There is the very interesting and fine theory of S. F. Smith for the origin of cockles‡ but there were no experimental proofs for their accuracy. The usefulness of a theory, however, is only manifested, if the theory is proved to be absolutely right and correct.

How would it be possible to prove the correctness of the irregularity of Smith's theory? Our idea was simple. If we could use the Smith theory to produce cockles in paper after a given pattern, that means cockles of a certain size and number on exactly determined spots, this would mean without any doubt the full justification of Smith's theory. Beyond

‡ Smith, S. F., "Dried-in Strains in Paper Sheets and Their Relations to Curling, Cockling, and Other Phenomena," *Proceedings of the Technical Section* 31: S.107 (1950).

Cockled Areas = Drier Areas before Drying
Flat Areas = Moister Areas before Drying
Unbl. Spruce-Sulfite, 60 °SR
Substance Weight: 75 g/m²; Drying-Temperature: 80 °C

Fig. 14. Cockling caused by variation of water content

Cockled Areas = Light Areas before Drying
Flat Areas = Heavy Areas before Drying
Unbl. Spruce-Sulfite, 69 °SR
Substance Weight (average): 75 g/m²; Drying Temperature: 80 °C

Fig. 15. Cockling caused by substance variation

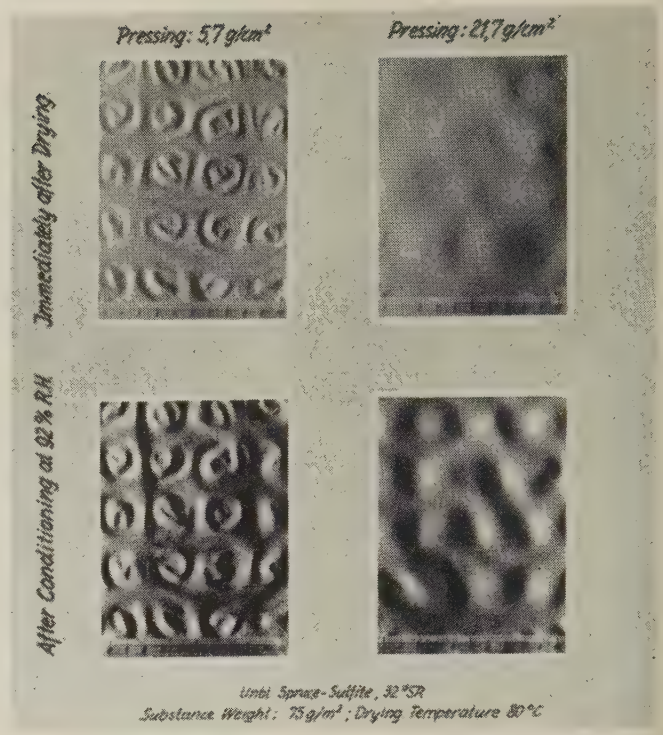
Pressing: 5,7 g/cm²
Pressing: 21,7 g/cm²
Immediately after Drying
After Conditioning at 92 % R.H.
Unbl. Spruce-Sulfite, 32 °SR
Substance Weight: 75 g/m²; Drying Temperature 80 °C

Fig. 17. The effects of pressing and conditioning on cockling

that it would offer the possibility of investigating experimentally all working conditions of the paper machine which influence the cockling.

Smith's theory says that cockles originate by dried-in strains. These strains are derived from the unevenness of shrinking during the drying. If the moist paper shows a spot with a lower water content, this spot dries more quickly than the surrounding area which holds more water. This area which therefore dries more slowly does not show any shrinking in the beginning, which means that it prevents the shrinking of the spot which dries more quickly, so that this spot shrinks under strain. If all the other spots are drying too and the paper, so to say, shrinks as a whole, those parts which have dried first under tensile strain and consequently remained larger, form cockles. All causes which make the drying speed different in different parts of a piece of paper must therefore produce cockles.

We made the attempt to produce cockles. To do it according to Smith's theory, it was necessary to take care that at the drying process of a sheet varying speeds of drying were distributed all over the paper.

Figure 13 shows how we induced the cockling. By cockling, we understand the departure of the sheet from the true plane. We get a picture which sharpens and emphasizes the visual impression by putting the sheet between two slides with a space of 0.8 mm. which are inclined to the horizontal at an angle of 3°. We illuminate with the arrangement shown in the picture and then we photograph. The left side shows a paper free from cockling; at the right, a cockled sheet.

The experiments were carried out by forming moist sheets and drying them on an oil heated, specially constructed plate. Differences in the drying speed between different areas of the sheet were produced by using certain patterns.

With sheets, which before the drying to a uniform substance weight showed areas of high and small moisture content, we obtained the models of Fig. 14. In all four cases, the cockles occurred, corresponding to Smith's theory where there was a dry area, whereas the smooth areas correspond to those of a higher moisture content. The two pictures at the top differ from those at the bottom by the difference in the pattern, that means the spaces between the moisture and the drier spots were different. The two left pictures show circular spots which were drier, the two right pictures circular spots which were moister than the rest of the areas.

Figure 15 is valid for a uniform moisture content, but for

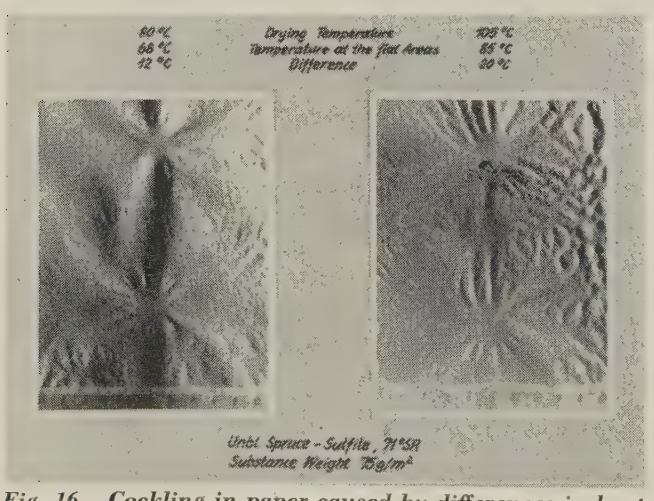

Fig. 16. Cockling in paper caused by differences in heat transmission

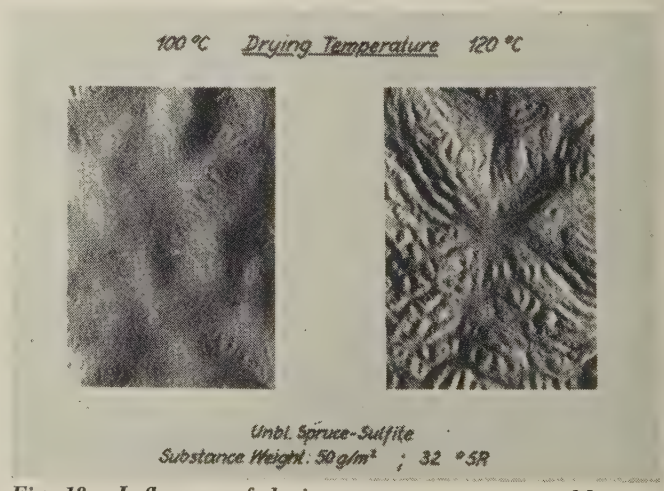

Fig. 18. Influence of drying temperature on cockling in paper

Fig. 19. Influence of substance weight on cockling in paper

areas of a different substance weight. The result is according to its principle the same as before. The cockles occur at the areas with the smaller weight or thickness where the drying is faster and where therefore tensile strains are dried in. The smooth spots correspond to the higher substance weight. Again there is the same difference in the pattern between the picture at the top and at the bottom; on the left, the circular areas are thinner, on the right, thicker than the surrounding areas.

Also differences on the heating surface in regard to heat transmission must theoretically result in cockling. That it is so is shown in Fig. 16. On the left, the temperature on the circular areas was 12° lower than on the remaining surface; on the right, the difference amounted to 20°. On the areas, where the temperature was lower and the drying occurred more slowly, the paper was plane in both cases, but in the neighborhood, cockles were formed. That is more obvious on the right picture because there was a greater difference in heat transmission.

Figure 17 shows a very important effect. The pictures on the left show a paper which was pressed against the heating surface with a slight pressure on the right with a strong pressure. Though, the paper showed an inclination to cockling due to the intentional uneven distribution of the moisture content, the cockles were altogether avoided on the right picture. Owing to the comparatively high pressure, only slight differences in the shrinking could occur and consequently also no greater dried-in strains. Below, you see what happened when the dried papers were conditioned in moist air of 92% R.H. The paper which had been pressed against the heating surface only slightly remained practically unchanged, but the other one now showed a very distinct tendency toward cockling.

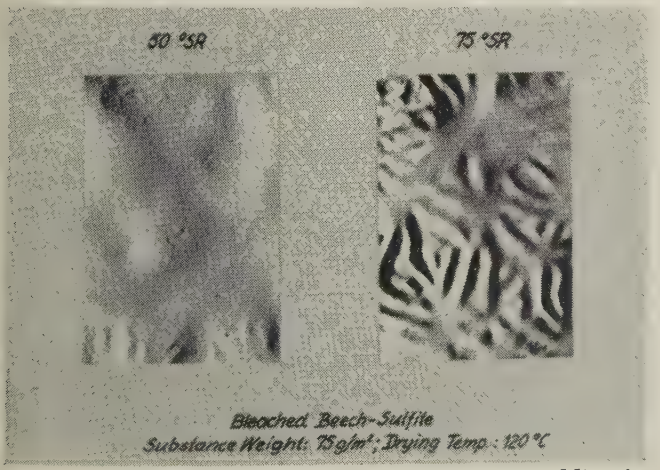

Fig. 20. Influence of beating degree S.-R. on cockling in paper

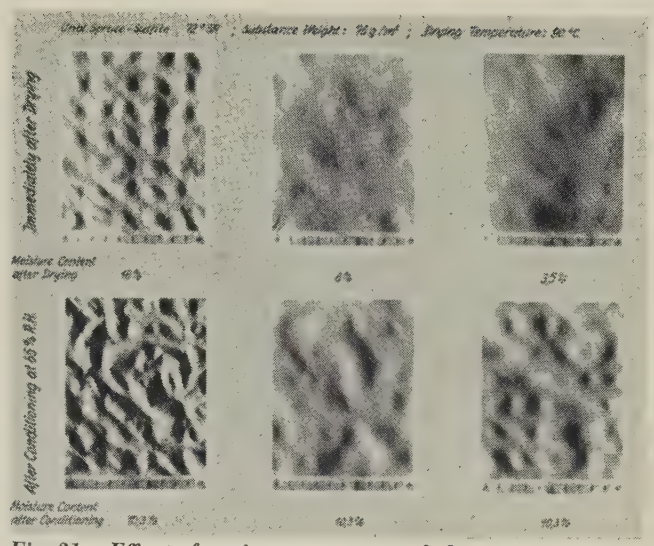
Immediately after Drying
Moisture Content after Drying
After Conditioning at 65% R.H.
Moisture Content after Conditioning

Fig. 21. Effect of moisture content of the paper and conditioning on cockling in paper

There are several influences that increase the tendency of a paper toward cockling. A higher temperature of the heating surface is less favorable than a lower one (Fig. 18). The theory also indicates that dissimilarities in substance weight or in moisture have more effect with thinner than with thicker papers. This is to be seen on Fig. 19. Since the tendency to shrinking, so important for cockling, increases with the growing slowness of the stock, the danger of forming cockles is particularly great with papers made from slow stocks. This is shown by Fig. 20.

Investigating the influence of conditioning more thoroughly, papers with an uneven distribution of moisture were dried to varying moisture contents of the finished sheets. The sequence of the three pictures at the top of Fig. 21 shows that immediately after the drying, the paper with the highest moisture content proved to be worst, the one which was dried to the highest degree best. The three papers were exposed to an air of 65% R.H. till they all had the same moisture content of 10.3%. The originally moist paper was the least satisfactory, the middle one which absorbed some moisture the most satisfactory. The initially overdried paper that quickly absorbed much moisture was not so good. Therefore, to avoid cockles, a minimum dry content of the machine-finished paper must be obtained. Furthermore, care must be taken that the paper, when stored, does neither increase nor decrease its final moisture content, whereby the decreasing or losing of moisture proves to be especially unfavorable.

Thus Smith's theory could be proved as to be correct. There is always a tendency toward cockling if the paper with regard to moisture and substance weight does not arrive evenly at the drying part. This tendency grows with increasing slowness of the stock and decreasing substance weight of the paper. It can be efficiently checked by a strong pressure of the paper to the heating surface. It is moreover very important to choose a not high final dry content and an adequate relative humidity of the air which later will surround the paper.

Since the shrinking occurring with the drying is decisive for the origin of cockles, we must assume that the influence exerted by the kind or nature of the pulps depends on their tendencies toward shrinking. We found out that short-fibered pulps, such as from beech and straw, shrink less and form fewer cockles in the paper than the long-fibered wood pulps, if the stock is free. But with a slow stock, they shrink more than the long-fibered wood pulps and they also correspond with the long-fibered wood pulps as to the cockling. Papers made only from groundwood do not show any cockling.

I may emphasize that these examples, I dealt with, were only examples indeed but they do indicate the direction we follow in our research work. The results are made to directly serve the teaching.

Instrumentation in the Kraft Cooking Process

JOSEPH F. KEYES

THIS paper covers briefly the development of instrumentation in the sulphate cooking process at the North Carolina Pulp Co.

In 1939 or 1940, the first instrument for automatic cooking was purchased for one digester. The instrument company stated that they had an instrument which would control the temperature-pressure relationship by throttling or controlling a gas-off valve. The instrument did not work, and later it was learned that it would have been remarkable indeed if it had worked under the conditions that existed at that time.

In 1945, another instrument was purchased from another company and was represented as being the latest thing in digester gas-off control, something that would work. This instrument proved to be about the same as the original instrument—a pressure-temperature controller that could be set to maintain a given differential between the pressure and temperature during the digester cook cycle. This instrument did not work either under the then present conditions. It was assumed that there was something wrong with the instrument and so the instrument company was requested to send some engineers to get the instrument operating, or the instrument would be returned. In a few days there were two instrument engineers on hand.

A gas-off blow back system was installed in the process. Several modifications were made in the gas-off strainer. Some modifications of the control instrument itself and better control of the steaming of the digester resulted in the installation of a time cycle steaming control, as well as automatic gas-off control. Some 6 months after this concentrated effort began, ten additional sets of instruments were purchased. This installation resulted in a savings of 300 to 500 lb. of steam per ton of pulp with considerable saving in liquor pull over from digesters, and completely eliminated the manual manipulation of gas-off and steaming valves to the digesters. It is believed that a more uniform set of cooking conditions carry over from shift to shift.

We remember when the mill first started up, we had a cook who kept a $^3/_4$-in. plank about 10 in. wide and 12 in. long in his hand all the time. He would put this plank on top of the digester and stand on it to tell how the cook was processing. If the digester was not rocking and he could feel no disturbance from the digester through his feet, he was dissatisfied with the way the digester was behaving. We had other cooks who were not satisfied unless the digester was pulling over a little liquor. As a matter of fact, in 1938, we had a consulting firm install a turpentine recovery system. When this system was installed it was only a few hours until we realized that the condenser was too small if we were to gas-off as freely as the operators then thought necessary. There was an assortment of from 2 to 4-in. gas-off valves on these five digesters. First, $^3/_4$-in. orifices were installed back of the gas-off valves and the operators could not tell the difference except that they liked the orifices because they got a better whistling noise. This made it possible to recover some turpentine. Later all the gas-off valves were changed to 1-in. high pressure angle type and the operators liked these because they gave even more whistle than the orifices. There was quite a divergence of opinion about strainers at one time and we actually changed the type of digester strainers several times. With the present instrumentation and with the work that was done in developing the present instrumentation, it is believed that something was learned about digester strainers. It was also learned that, when the digester gets up to about 20 or 30 lb. pressure, it's a good idea to ease off on the steaming for about 10 min. and give the digester time to clear itself of air and the steaming cams are cut to do this.

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When these instruments were installed, it was estimated that an instrument department man would be needed 8 hr. a day, 5 days a week, to keep them in first class operating condition. It has been found that approximately $1^1/_2$ hr. a day, 5 days a week, is all that is necessary.

About a year ago the pressure taps were changed from the top of the digester to the bottom. They are now connected to a 3 by 8-in. pot that is purged with water, and the pot is connected to the spool between the digester and blow valve. The reason the taps were placed in the bottom was that the manufacturers felt that steam pockets in the bottom of the digesters would be eliminated and the digesters would gas-off and relieve themselves of the noncondensable vapors, thereby circulating and getting into equilibrium with the steam much quicker. The pressure on the bottom is equal to the steam pressure plus the hydrostatic head of the digester. The instruments are duplicating themselves day after day. Successive cooks are more uniform because the conditions are the same for each cook, and the human element of different cooks steaming and gassing differently from cook to cook has been eliminated.

The automatic controls are more economical as they produce a more uniform pulp with less rejects and less steam consumption. It is doubted if one man could successfully operate 11 digesters manually, especially where two grades of pulp are produced and two different cooking times used. The digesters are equipped with electrically operated blow valves controlled from operating floor.

The blowdown system is equipped with an automatic controller to condense the steam from each blow. The escaping steam from the cyclone tank passes over a thermocouple. This starts a circulating pump and opens a valve in the water circulating line, permitting the cold water to be pumped to the condenser.

About 6 months ago, the consistency controller was changed to the hard side blow tank. The blow tank is equipped with a kilowatt recorder and a liquor flow rate to the blow tank. The amount of liquor added to the blow tank was governed by the load on the agitator motor.

A pressure tap was installed in the header on the discharge side of the cyclifiners, which is equipped with a water purge and a sight flowmeter. The pressure on the header to the refiners is controlled by an air line controller with reset rate response. By setting this instrument a constant pressure is maintained on the header, and this pressure controls liquor dilution to blow tank. Since using this, the refiners do not lose their load and run empty. The refiner plates have a little longer life.

The consistency of the soft side blow tank is controlled by the kilowatt load on the agitator motor.

The digesters at the semichemical pulp plant are equipped with temperature and pressure controls. The gas-off is operated manually.

The liquor charge is pumped to the digester by a liquor filling system. One index on the controller starts the pump from white liquor storage and pumps the required number of gallons of white liquor to the measuring tank. The second index pumps the required number of gallons of black liquor to the measuring tank. When the digester is ready to be charged, the operator starts the liquor pump and fills the digester, then the filling cycle is repeated. The dilution liquor to the blow tank and refined stock tank is controlled by the kilowatt load on the agitator motors.

Industrial instrumentation is changing rapidly and drastically. Automatic instrumentation is the trend today. Its objective—to substitute automatic devices for all this human effort, sparing man for maintenance and supervisory roles. The larger process industries have been utilizing instruments for many years, and so have built up a store of knowledge and established staffs to handle instrumentation matters.

We might well find ourselves in the position of the visitor when being shown through the plant. The guide explained

that everything in each department was automatic and only one or two operators were needed to operate the department. The visitor noticed more employees than this, and asked what so many men were doing. Oh, replied the guide, "they take care of the automatic instruments."

Presented at the Eighth Alkaline Pulping Conference of the Technical Association of the Pulp and Paper Industry, Birmingham, Ala., Oct. 6–8, 1954.

The G.C.M.I. Friction Tester—An Instrument for Measuring Coefficients of Friction of Paperboard

JOHN G. TURK and RICHARD MAXSON

THE slipperiness of some of the corrugated board used in boxes causes trouble in palletizing and handling. This difficulty results in lost time and is a safety problem in the warehouses of those companies handling both empty and filled glass containers in boxes.

When the problem was originally outlined, it was felt that as a first approach to the matter an instrument was needed which would precisely and accurately measure the coefficients of friction of either component linerboards or combined corrugated board. It should be noted that while slipperiness and smoothness are often confused, and while there may be a correlation between the two, the instrument described below was designed to give information about the former by measuring the coefficient of friction.

First a few words about friction. Consider a block of weight W placed on a horizontal surface. In order to move the block, a certain force F_s will be required to start the block in motion; and once the block is in motion, a smaller force F_k will be needed to maintain an unaccelerated motion. Since two forces of different magnitude are involved, it is necessary to define two coefficients of friction:

$$\mu_s = \frac{F_s}{W} \text{ and } \mu_k = \frac{F_k}{W}$$

where μ_s is called the coefficient of static (starting) friction and μ_k is called the coefficient of kinetic (sliding) friction. Therefore, the problem of determining the two coefficients of friction involves measuring the weight of the block and the forces required to start motion and continue motion. It makes no difference whether the block moves, as described above, or whether the surface moves and the forces required to hold the block stationary are measured. This latter arrangement is used in the G.C.M.I. instrument.

The G.C.M.I. friction tester incorporates a table, running on a track, with provision for attaching a specimen of either linerboard or corrugated board to its top surface. It is possible to test specimens of single or double-wall board of any flute size or linerboard of any grade.

The analogue of the block in the above discussion is a slider with provision for attaching a specimen to the bottom and placing additional weights on its top surface. The total weight of slider, specimen and additional weights has been standardized at 2.0 lb. This results in approximately the same pressure (about 0.3 lb. per sq. in.) on the 2 by 3-in. upper specimen as would be found in a box packed with filled glass containers.

The table is driven at constant velocity by a double-action hydraulic cylinder and piston. This type of drive was chosen to eliminate vibration since it is evident that vibration could affect the results. The table velocity is controlled by a needle valve which regulates the forward speed within very close limits. A rapid return of the table is provided by a check valve arrangement. The table velocity is standardized at 0.1 in. per sec. Although this velocity is probably one or two orders of magnitude less than those encountered in practice, this smaller velocity makes a friction determination comparatively simple with the present apparatus. Also, some experiments (not on paperboard) indicate that the velocity dependence of friction is rather small. Nevertheless, further work is being planned to study this aspect of the problem, and it may be that the present standard will have to be revised.

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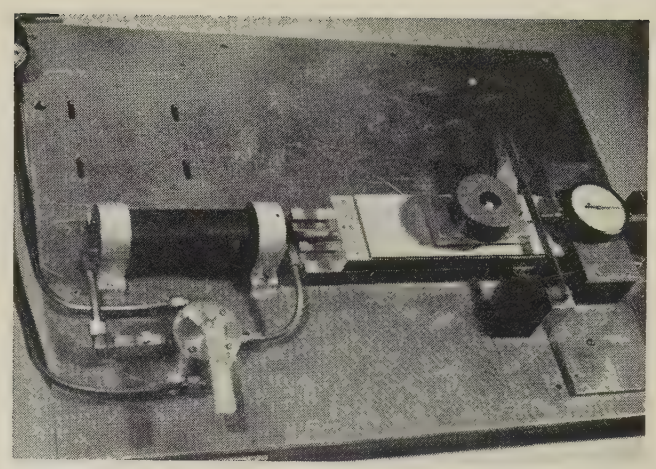

The G.C.M.I. friction tester

The force measuring device incorporated in the instrument consists of a beam with simply supported ends; the deflection of which is measured with a dial micrometer. The inherent simplicity and ease of calibration recommended this type of weighing member, and it has worked out very well in practice. The beam is so designed that 1 lb. force will result in 0.1 in. deflection, thus making the instrument direct reading in terms of force (0.001 in. deflection is equivalent to 0.01 lb.). A rounded anvil on the front of the slider contacts the beam at its center. The friction force then causes the beam to deflect, this deflection (equivalent to force) being read from the scale of the dial indicator.

When friction is measured with apparatus similar to that described above, the sliding of one specimen on the other is not regular. Instead the relative motion of the two specimens is a series of sticks and slips. Some experimenters, notably Bowden (*1*), have interpreted this as being a fundamental property of friction, while others, including Blok (*2*), have analyzed this behavior as being due to the nature of the apparatus. In any case, it seemed wise, in the design of an instrument for semiroutine testing, to provide means for damping out this oscillation. Therefore, an oil-filled dashpot was incorporated in the apparatus. Experiments have shown that sufficient damping can be conveniently provided in this manner to reduce the "stick-slip" to smooth motion between the specimens.

It is believed that this instrument effectively performs the function for which it was designed. However, instrumentation studies have not been completed, and there may be modifications of the tester in the future. It seemed advisable, nevertheless, to publish this note at this time since there has been a great amount of interest shown in slipperiness in recent months. Slipperiness is an important characteristic of board; therefore, the coefficients of friction should be considered by linerboard producers in the development of new liner finishes. Any comments or requests for further information will be welcomed by the G.C.M.I. Laboratory.

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RECEIVED March 17, 1955.

Modern Methods of Preparing, Cleaning, and Treating Waste Paper for Paper and Paperboard Use

F. MADSEN

In recent years much emphasis has been placed on the subject of pulping and refining. This is rather natural as these problems are of the utmost importance to the papermaker. Because of the intensified research and investigation of the stock preparation system, the present paper will not be entirely new, as the methods to be described later for modern pulping and refining have already been recognized in Scandinavia and are already operating in several of the larger paper and board mills.

As it is known that a paper was read about the availability of waste paper in Scandinavia and the World at a previous meeting, the author will not endeavor to bring forward any statistics about the amount of waste paper available, but limit this discussion to the technical side of the waste paper treatment.

As by far the majority of waste paper used in paper mills and board mills consists of mixed dirty waste paper, which in England is called grade 13, containing all types of junk and refuse, first to be described is a slushing and cleaning system for mixed waste paper.

MIXED DIRTY WASTE PAPER SLUSHING AND CLEANING

The fundamentals behind the development of the modern waste paper slushing and cleaning system are based on the fact that it is preferable to separate as much of the dirt from the usable fibers as possible before treating the fibers in refiners or jordans. This is of very great importance. It has been found from many installations that, if the dirt particles in the waste paper are allowed to follow the fibers into the actual refining system, there will be great difficulty in getting a clean, speck-free sheet. All will realize that a considerable amount of horsepower and time will be needed if these dirt particles are to be brushed out in the beater or in the refiners and jordans. In order to brush out this dirt it is, therefore, necessary to apply very heavy refining, with the result that damage is done to the usable fibers. By this overtreatment of the good fibers, the final strength characteristics of the board or paper will suffer, and you will have a stuff with, first of all, very low freeness (that is, high Schopper-Riegler figure), and especially the bending and folding strength of the board will suffer. With the trend being higher speeds on paper and board making machines, the question of freeness cannot be overemphasized, and all will realize that it is of utmost importance to produce the pulp with as high a freeness as ever possible.

Reverting to the question of the impurities in mixed waste paper, these can be broken down into two main groups: namely, impurites having a specific gravity higher than water (such as bricks, stones, nuts, bolts, paper clips, pins, sand, etc.) and secondly, impurities having a specific gravity the same or less than water—the so-called floating trash (containing such items as rags, ropes, wet-strength paper, cork, matches, rubber bands, cellophane, etc.). While the cleaning of the waste paper previously took place in many mills at a sorting band, where girls were sorting out the various foreign materials, a wet cleaning system has now been developed, which, fundamentally, is based on the two above-mentioned classifications: namely, impurities with gravity higher than water and impurities with gravity less than water.

We can, therefore, divide the slushing and cleaning of mixed waste paper into the following steps:

1. Disintegration and slushing of waste paper bales (Hydrapulper).
2. Removal of large heavy particles (junk remover or junk box).
3. Removal of large stringy impurities such as rags, ropes, wires, etc. (ragger).
4. Removal of high gravity dirt, such as paper clips, sand, small pebbles, stones, etc. (centrifugal screen).
5. Removal of floating trash, such as matches, corks, rubber bands, wet strength and cellophane, etc. (Classifiner).
6. Recovery of usable fibers in the Classifiner rejects (disintegrator and Slectrap or flat screen).
7. Concentration and thickening of accepted fibers (thickeners).

At this stage reference is made to Fig. 1, which shows the complete Shartle mixed paper pulping and cleaning system for 100 tons per day. This is the Shartle-Dilts cleaning system which is developed on the principles just described and which shows the types of machines generally used and which have been in operation in many mills in the United States and Europe for years.

In the figure it will be seen that the waste paper is slushed continuously in a 16-ft. diameter Hydrapulper, generally at a consistency of about 2 to 2½%. By means of the ragger, the wires, ropes, and rags are continuously removed, forming a continuous rag rope which is drawn out by the automatically operated ragger. In this Hydrapulper, the very large heavy particles such as stones, bolts, and other big particles, are rejected into the junk remover from which they are continuously removed. The slushed fibers which contain smaller particles of dirt and floating trash, are then continuously overflowing through the regulating box into a centrifugal pump which delivers the stock at high pressure to the centrifugal separators, shown here as the Hydrafuges. From the Hydrafuges, the smaller particles with specific gravities higher than 1 are continuously rejected by means of a screw mechanism, and the accepted stock is discharged into a headbox with an overflow back to the discharge side of the regulating box. By means of a regulating valve in this headbox, the necessary and required amount of fiber suspension is taken to the Classifiners where floating trash is continuously rejected. The rejects from the Classifiner are treated in a disintegrator, in which the larger pieces of paper are exposed to heavy turbulent action, thereby separating as many of the usable fibers as possible from the actual trash. The disintegrator pump discharges into a Selectrap of flat screen where the floating trash is rejected while the recovered fibers are returned to the Hydrapulper. The accepted stock from the Classifiners, now being cleaned and freed from the impurities, is concentrated in the thickeners to 4 to 5% and dumped into the thickener dump chest ready for further treatment.

At this point, it would probably be helpful to give a description of each of the different functions as described above, with a special description of the type of machinery used.

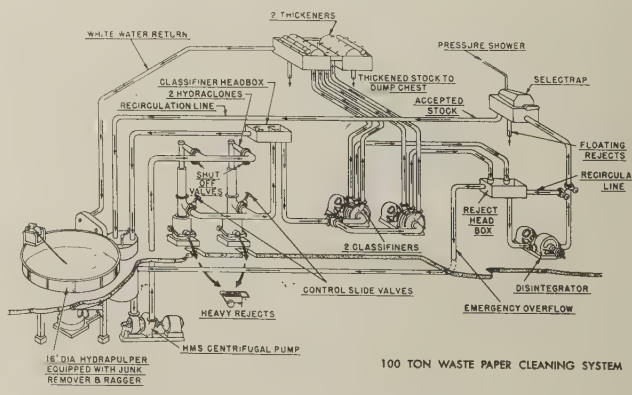


Fig. 1. Complete mixed paper pulping and cleaning system. 100 tons per day

F. Madsen, Black-Clawson International, Ltd., London, England.

Feeding of the Pulpers

An important factor for the correct operation of the Hydrapulper is the constant rate of feeding the waste paper into the pulper. By installing continuously operating conveyors, the handicap of hand feeding will be overcome, no longer relying on the human element. By means of conveyors, a steady flow of raw material to the Hydrapulper can be obtained, and with a steady flow of dilution backwater, a very close control of the consistency. It is, therefore, now common practice to install Hydrapulpers suitably fitted with conveyors to feed them mechanically and fast, enabling them to slush their maximum capacity of waste paper. It may be useful to install a photoelectric system to govern the start and stop of the conveyor. The waste paper conveyor runs from the waste paper storage, directly into the Hydrapulper. In the waste paper storage room, the waste paper bales are taken by a fork lift truck and loaded directly onto the conveyor. When the fork truck is close to the conveyor, it breaks the beam of light governing the photoelectric cell, and the conveyor stops while the fork truck is unloading. When the truck is reversing, the beam of light starts the conveyor running again. By means of this conveyor, a considerable amount of labor will be saved.

Figure 2 shows three apron-type conveyors which are serving continuous and batch Hydrapulpers recently installed in an American board mill. This shows the dumping of waste paper bales from the conveyor into the Hydrapulper.

Disintegration and Slushing

The heart of this stock preparation system is, of course, the continuous Hydrapulper itself. Everyone is probably quite familiar with the construction of the Hydrapulper, so it is not necessary to go into further detail except to mention that the continuous extraction of pulp from the Hydrapulper is done through the perforated extractor plates in the bottom of the Hydrapulper. The holes in the extractor plates vary with the application of the Hydrapulper, and generally for mixed waste paper application $^3/_8$-in. diameter holes are used. The Hydrapulper itself is a very rigidly constructed machine, and an enormous amount of research and testing has been carried out on this machine before it was introduced to the market. Another feature, which proves this, is the fact that during the last 12 to 14 years there has been no appreciable alteration to the construction of the Hydrapulper. With some 1200 units already installed it is believed that a lot of operating experience has been gained and that the introduction of this machine was the greatest advance made in waste paper treatment since the breaker beater many years ago. In the case of large coherent masses of pulp, such as pulp bales or waste paper bales, the initial submergence may be insufficient to break down the mass, but as soon as it is once acted upon by the impeller in the bottom of the Hydrapulper tub and returned to the surface, it is again submerged and again driven into the zone of action of the impeller. A few repetitions of this action are usually sufficient to break down even the largest masses of pulp, such as entire bales. Meanwhile, the fiber separation proceeds with respect to the smaller pieces of pulp.

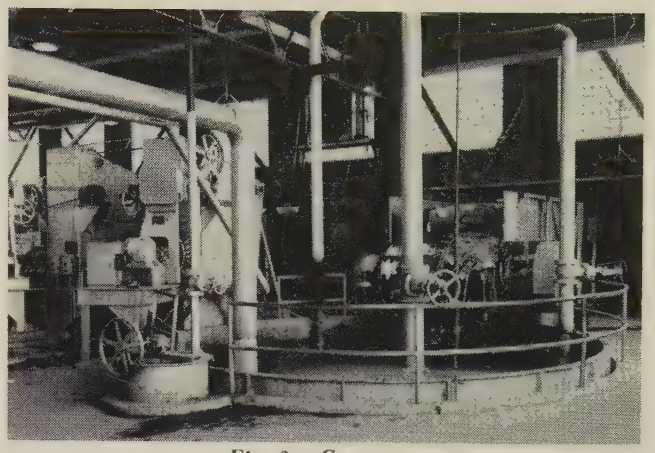


Fig. 3. Conveyor

The pulping action results from two distinct functions of the Hydrapulper impeller: first, the mechanical derangement of the pulp and paper sheets, and second the hydraulic frictional drag between the surfaces of the nozzle of high velocity stock leaving the periphery of the impeller and the relatively slow-moving body of stock in the Hydrapulper tub.

The point at which the pulping operation should be discontinued in batch operating Hydrapulper, varies with the types of furnish used.

However, after a certain stage, the efficiency of any pulper drops rapidly as illustrated in Fig. 5 where fiber separation is plotted against time or horsepower per ton per day. Pulping after point A becomes simply a waste of power, and at this point the stock should be taken from the Hydrapulper to high-speed refiners for final defibering.

Based on the average data from several hundred mill installations, a maximum consumption of 2 hp. per ton per day, varying in extreme cases from 0.35 to 3 hp. per ton per day, but generally between 1 and 1.5 hp. per ton per day can be pulped efficiently.

Figure 6 shows Hydrapulpers built of different materials: the Hydrapulper at left is of all welded steel construction, while the one at right is of standard cast iron construction. Both are driven by the same type heavy duty, right angle gear drive.

The design of the Hydrapulper was concentrated on a machine to perform only the function of pulping and part

Fig. 2. Three apron-type conveyors recently installed

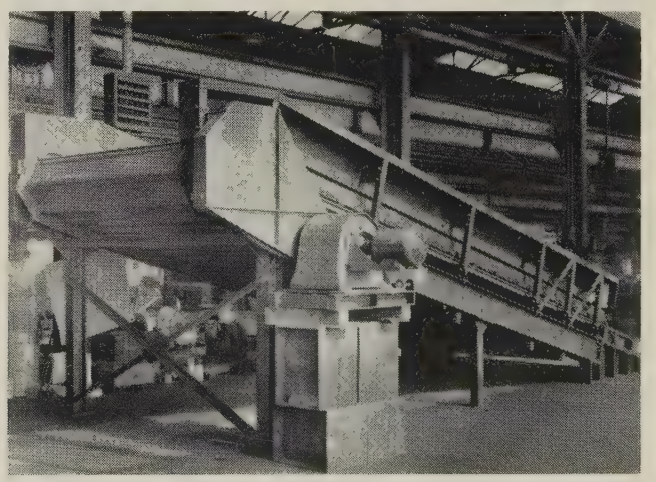


Fig. 4. Conveyors

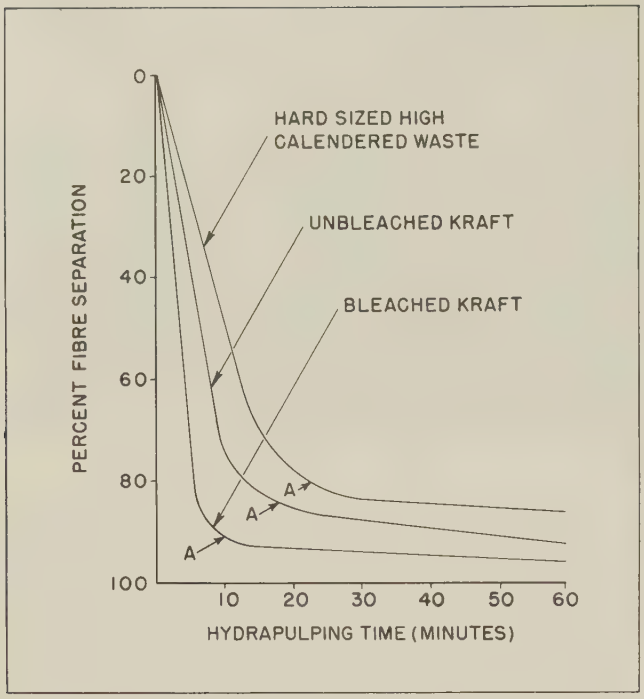


Fig. 5. Hydrapulper curves

defibering. Every conceivable pattern of tubs—square, round, elliptical, clover-leaf, and triangular tubs—all in conjunction with many types of impeller or rotor designs were considered. After experimenting with all these designs and being guided by actual installation experience, the most efficient machine was simply a cylindrical tub with a horizontal impeller in the center on top of a vertical shaft.

It might be of interest to mention that, even if the Hydrapulper from a casual survey looks a fairly simple machine, there are factors of extreme importance for successful operation: such as, for example, the ratio of the impeller diameter to the tub diameter, the speed of the impeller in relation to tub capacity, and type and consistency of furnish. These critical factors have been laid down in a set of standards based on actual operating experience. The connected and applied horsepower is governed by the capacities, consistencies, impeller diameters, and speeds.

Some may be wondering why the rotor of the Hydrapulper is placed in the bottom of the tub and not in the vertical plane as in certain types of pulping machines on the market today. From experience it has been found that a much more efficient pulping is obtained with the rotor situated in the bottom of the tub. The Hydrapulper can, therefore, be operated with any height of stock in the tub and still give efficient pulping. Further, there is very little danger of foreign pieces of wire,

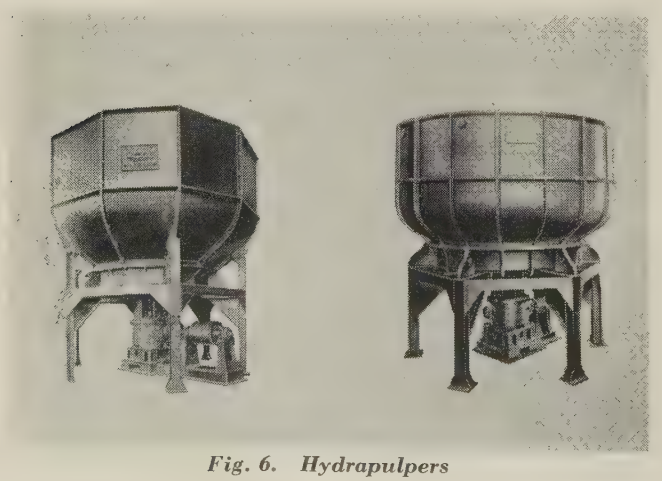


Fig. 6. Hydrapulpers

Fig. 7. Bottom of Hydrapulper

rope, strings, etc., which are so predominant in waste paper, winding themselves round the shaft. It has also been found that, with the rotor in the bottom of the tub, it is possible to get up to higher consistencies. Generally speaking, batch units can operate at consistencies up to 10 or 12% and continuous units vary from 1 to 3% on dirty mixed waste paper application up to 5 or 6% on clean stock duties.

Figure 7 shows a photograph of the bottom tub section and drive of a waste paper continuously operating Hydrapulper. The very heavy-duty drive which is connected direct to the driving motor will be noticed. Through the hypoid or spiral bevel gear box, the speed of the motor is reduced to suit the speed of the rotor in the Hydrapulper. This picture also shows the continuous extraction of stock from the Hydrapulper extraction chamber to the regulating box. Inside the regulating box is an adjustable baffle, by means of which the level inside the Hydrapulper can be adjusted. From the discharge side of the regulating box, the pump delivers the stock to the centrifugal separators or sandtrap.

Removal of Rags, Ropes, Wires, etc.

Figure 8 shows the continuously operating ragger as developed by Shartle-Dilts, and in operation in a multitude of waste paper installations.

The ragger consists of a large metal spool of very unusual design, that fishes up the rags, wet-strength papers, etc., in the form of a rope. From the ragger, a few barbed wires are hanging down into the Hydrapulper, thus forming the initial rope. This rope catches the cut wires off the bales of dirty mixed waste paper, and is only required when starting a Hydrapulper when new.

A piece of the old rope, left in, serves to start the ragger after washout. The rope may be set to travel at varying speeds, depending upon the rag and wet-strength content of the furnish. The good fibers adhering to the rags are slushed back into the tub by a white-water shower arrangement, and tests show that only a very small amount of good fiber is lost with the rag.

Figure 9 shows the ragger in operation in an existing Hydrapulper. Note the very turbulent action of the Hydrapulper impeller which swirls the pulp round at a high velocity. It will be seen that the rag is dragged up from the Hydrapulper tub, and is discharged continuously on the back side of the ragger itself, as shown in Fig. 10.

Removal of Large, Heavy Particles

The junk remover is installed alongside the Hydrapulper tub and is connected to a slot in the bottom of the Hydrapulper tub by a junk chute which permits junk to drop to the

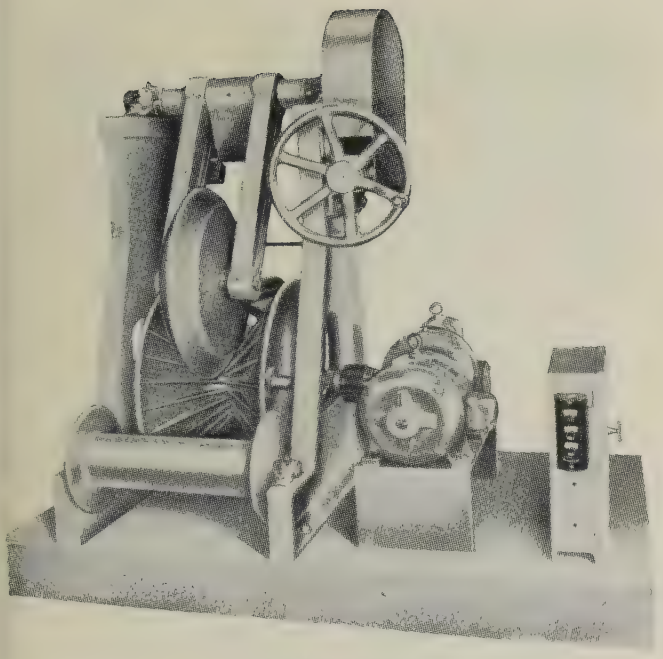


Fig. 8. Ragger

boot of the junk remover. An endless bucket conveyor, operating on the chain and bucket principle, removes the junk from the bottom of the boot as fast as it accumulates, by lifting it above the level of the stock in the Hydrapulper and discharging it into a junk box. In order to salvage fiber adhering to this waste, a perforated plate is installed in the bottom of the junk box, through which white water flows causing such fiber to return to the Hydrapulper tub.

Figure 11 shows the general appearance of this junk remover. Figure 12 shows how it is fitted to the Hydrapulper tub.

Figure 13 shows a view from the top, showing the endless bucket conveyor for removing junk, and also showing the junk box.

Centrifugal Dirt Separation

Since the very heavy dirt particles have now been removed the next object is to remove the smaller particles. The first system applied here is the centrifugal screen or separator in order to take out the smaller particles with a gravity higher than water. The dirt-laden stock is introduced at high pressure and accelerated to high velocity force as the stock spirals alongside the inner part of the wall.

Entering the separating zone, particles of high specific gravity are thrown outward and dropped to the grit chamber, while the spiralling main body is thoroughly cleaned, and flows continuously to the discharge port of the separating machine. As the rejected material of higher specific gravity is centrifugally separated from the stock, it drops to the receiving hopper and accumulates in either a compaction screw which forces it outward against a counterweighted door, or in a special chamber for collecting the dirt.

Figure 14 shows the principle of centrifugal separation. In order to get sufficient velocity, the stock must enter the separator at high pressure (about 22 to 25 p.s.i.) which pressure, during the stock travel through the spiral flight, dissipates into velocity which eventually causes the ejection of the high gravity dirt. It should be mentioned here that, in order to get adequate separation of the dirt, it is necessary to operate at a rather low consistency of about 0.6 to 1%, which is obtained by diluting the stock in the discharge side of the regulating box immediately before the separator pump.

Removal of Floating Trash

The next stage in stock cleaning is to remove the floating

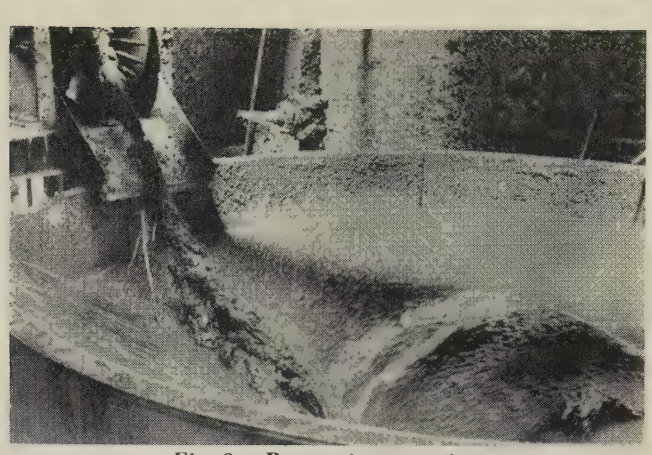


Fig. 9. Ragger in operation

trash. As mentioned in the beginning, it is very important to get rid of all this dirt, such as matches, rubber bands, cellophane, etc., before the fibers are treated in the beater or refiner machine. One of the big problems here has been to screen them out without clogging and overflowing of the screen. It will, therefore, be advisable to use a self-cleaning screening machine at this stage, and in Fig. 15 the outline of the Classifiner is shown. The operating principle will be better understood from Fig. 16, which gives a close-up view of the machine opened up. The stock from the Hydrafuge is entering the Classifiner through a pipe in the center on the right side of the picture. This pulp is being slushed and rotated by the very heavy impeller, furnished with scraper blades on the inside of the Classifiner between the two vertical screen plates. The accepted stock flows through the holes in the screen plates, and the rejects are automatically rejected through the orifice in the center part of the Classifiner. By means of the scrapers, the screen plates are continuously cleaned, and the possibility of clogging is, therefore, remote. The perforations in the screen plates will usually be about $^1/_8$ to $^3/_{16}$ in. diameter.

Fig. 10. Ragger in operation, discharge

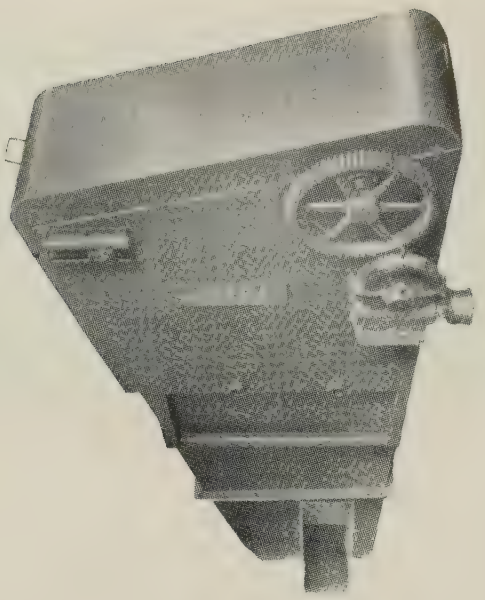


Fig. 11. Junk remover

The object of the runner is, first, to provide ample pressure to expel the heavy and light trash thus rejected, second, to centrifuge rejected material to a point outside the screening zone, and third, to clear material tending to felt over the holes. The installation of the Classifiner has so many advantages that it will just be mentioned that it throws aside for further treatment and salvage much stock still in the form of fiber bundles adhering to foreign material, instead of permitting this stock to go to waste. It also throws away rejects in an early stage and process, which later on would have damaged the jordans, machine screens, facecloths, etc. The wear on the Classifiner itself is concentrated to a few readily accessible, low-cost parts and can be controlled by regular inspection of the runner and resetting of the runner blades. Besides, this very compact screen does not take up very much room in the building.

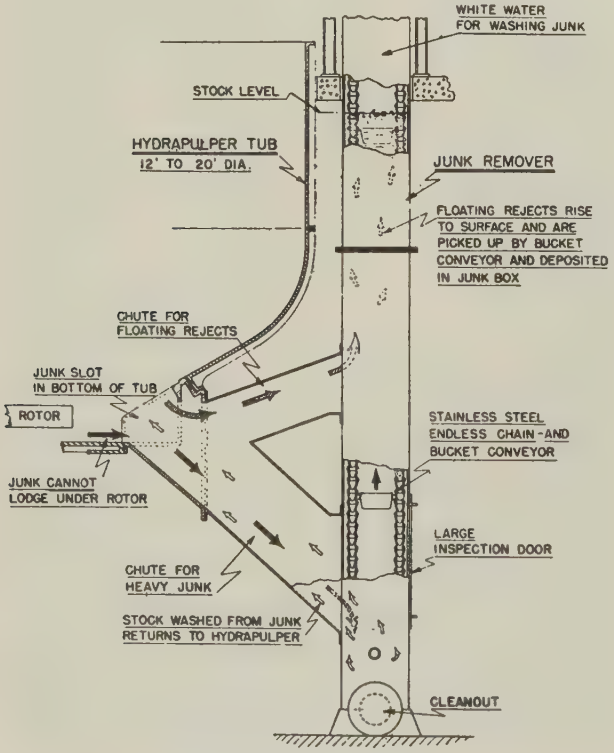

WHITE WATER FOR WASHING JUNK
STOCK LEVEL
HYDRAPULPER TUB 12' TO 20' DIA.
JUNK REMOVER
FLOATING REJECTS RISE TO SURFACE AND ARE PICKED UP BY BUCKET CONVEYOR AND DEPOSITED IN JUNK BOX
CHUTE FOR FLOATING REJECTS
JUNK SLOT IN BOTTOM OF TUB
ROTOR
STAINLESS STEEL ENDLESS CHAIN-AND BUCKET CONVEYOR
JUNK CANNOT LODGE UNDER ROTOR
LARGE INSPECTION DOOR
CHUTE FOR HEAVY JUNK
STOCK WASHED FROM JUNK RETURNS TO HYDRAPULPER
CLEANOUT

Fig. 12. Junk remover

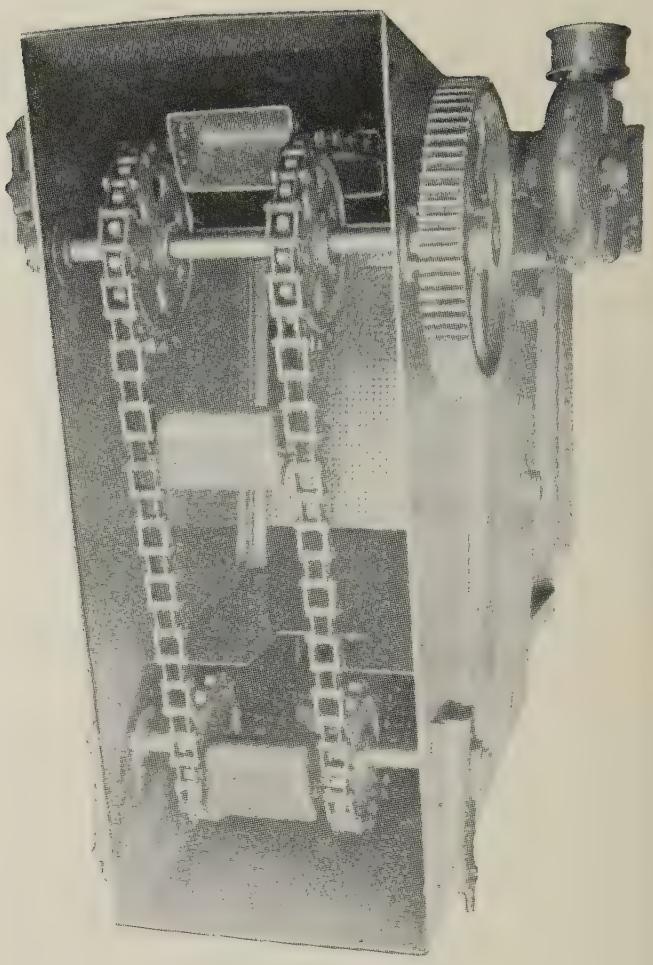


Fig. 13. Junk remover

Figure 17 shows the accepted stock pipes that go directly from the Classifiner into the thickener, and the reject pipe that carries the rejects from the center part of the two Classifiners onto the disintegrator pump.

Recovery of Usable Fibers in the Floating Trash

The disintegrator is an important unit in any dirty and mixed paper stock cleaning system. Its location in the mixed paper cleaning system is after the floating trash screen (such as Classifiner) and immediately ahead of the final floating trash screen. The function of the disintegrator is to break loose, or free by vigorous rubbing action, those fibers that still remain knotted or attached to unwanted material, such as staples, paper clips, orange peel, etc. In principle it is a conical type of refiner, which will not do any cutting or actual refining but just rubbing and splitting of the fiber bundles.

The stock is discharged from the disintegrator to a final screen, which rejects the actual floating trash itself, as mentioned before, while the accepted and broken up fibers return to the pulper for salvage.

It just needs to be mentioned now that the accepted stock from the Classifiner is taken directly to the thickeners where it is concentrated to a consistency suitable for further treatment in beaters or refining machines.

It will be appreciated that much attention has been paid to the question of cleaning before refining. However, as this cleaning only calls for an initial cost, is easy to operate, and is labor-saving, it soon pays for itself also by savings in the horsepower for final refining, and last but not least in improved quality. There is, naturally, quite a variety of other types of machines that can be used in these systems with greater or less success, but the author endeavored here to give as complete a cleaning system as possible, following the

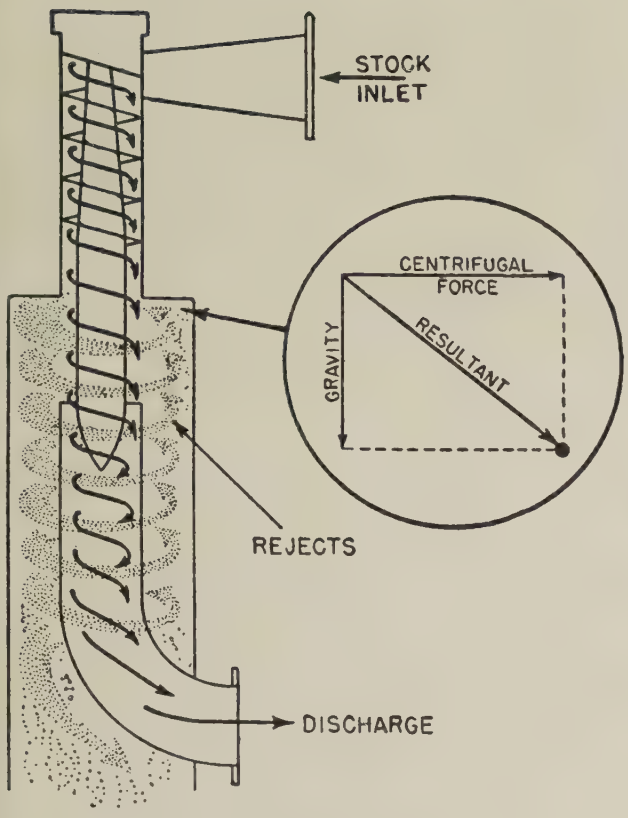


Fig. 14. Hydrafuge principle

theory of cleaning as previously described and generally outlined in Table I.

Defibering, Fibrillation, and Cutting

Depending on what type of paper or board is to be produced, the fibers that are now cleaned and concentrated to refining consistency will need final treatment in jordans or high-speed refiners, in order to finally defiber, fibrillate, and cut the fibers.

While, or course, the fibers from waste paper have already been treated before, it will be necessary to give them a slight refining, in order to separate the small fiber bundles, which have not yet been split up in the cleaning system. However, as all the impurities have been removed now, a very light treatment will generally be sufficient, especially emphasizing the brushing action and avoiding the cutting action as much as possible. In many existing installations, where the waste paper cleaning system has been modernized, the thickened waste paper stock is pumped directly from the thickener dump

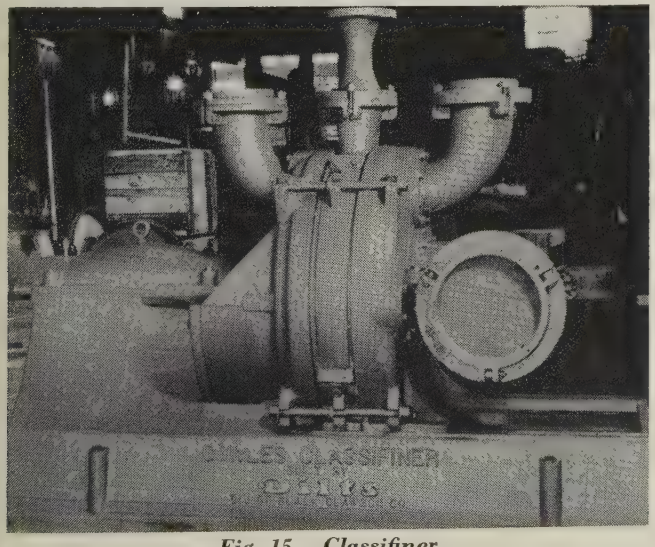


Fig. 15. Classifiner

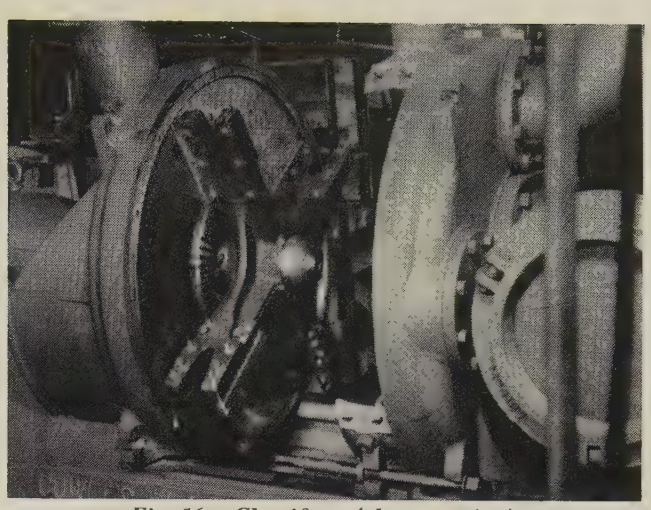


Fig. 16. Classifiner (close-up view)

chest into the beaters and given further treatment in the beaters.

However, the trends in modern paper practice have been to operate more or less continuously in high-speed refiners, instead of the old type Hollander beaters.

Let us for a moment consider what actually may happen to the fibers when they are brought into an area where they are subjected to the action of two objects which are made to pass one another in intimate proximity; such as the action of two passing bars, as is the case both in the conventional beater, the refiner, and the jordan.

With the two bars well apart, the fibers will be rubbed against adjacent fibers, which tend to fibrillate them to some extent, and to a reasonable large extent if the action is repeated over a period of time.

By bringing the bars closer, the fibers will be flattened down or brushed as they pass between the faces of the bars. This flattening or crushing causes the fibers to split along their length. Some fibers will be subjected to action over their entire length, while others will only be gripped at one

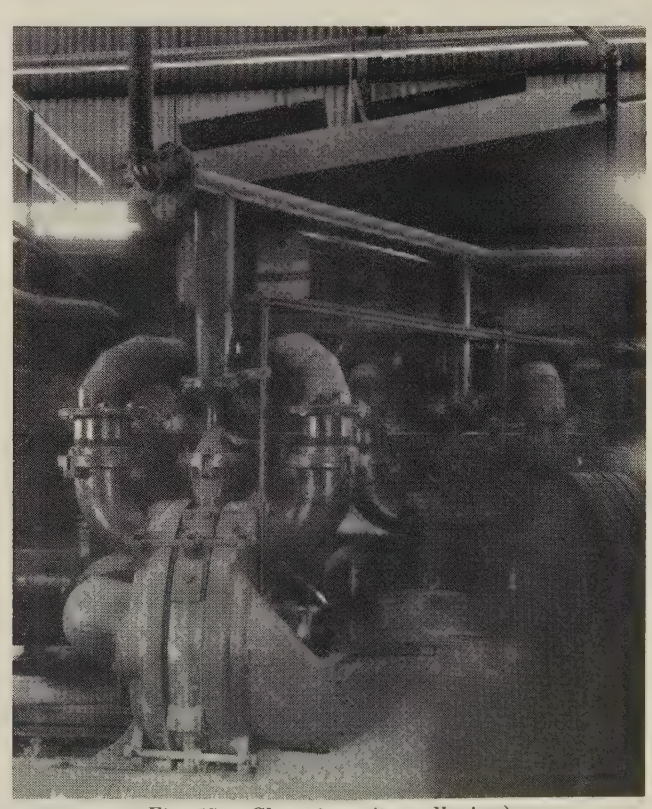


Fig. 17. Classifiner (installation)

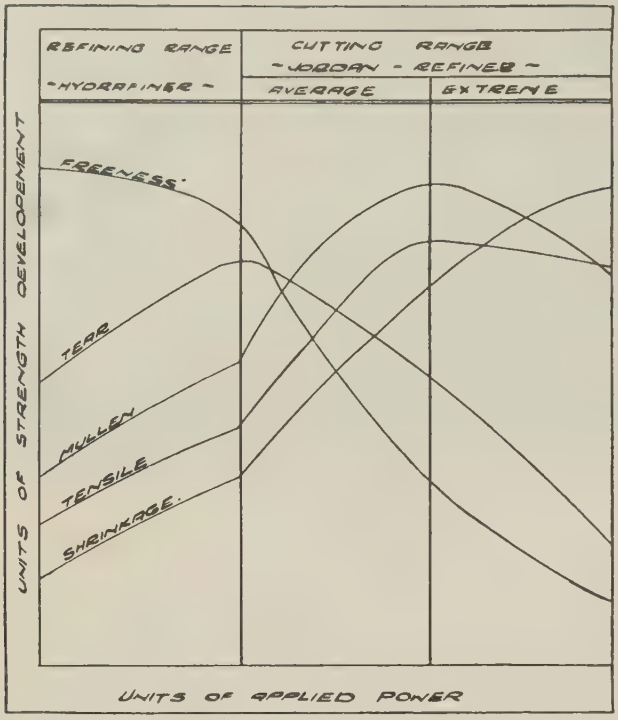


Fig. 18. Refining-cutting characteristics

end and crushed or broomed at that end. At the same time, the fibers will be rubbed on the surface, causing some of the integral fibrils on the surface to fuzz out or fibrillate.

If we bring the bars into passing contact or very close thereto, we will get a shearing or scissors action, and the fiber will be cut into two pieces over the edge of the bars.

So far, we have referred to the work done by the bars of the machine where the majority of the work is actually done. However, if the action is carried on at relatively high speed, there will be some work done fiber on fiber by the turbulence set up in the unit. This abrasion, fiber against fiber, is not

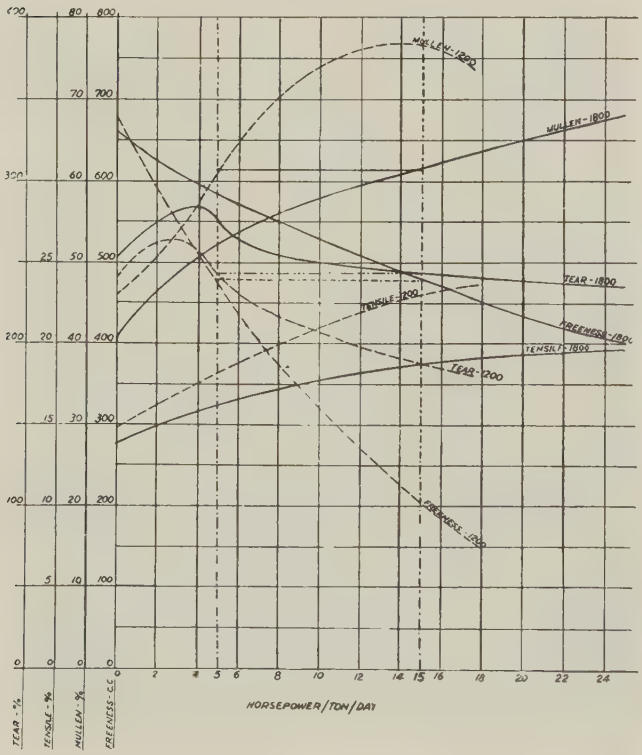


Fig. 19. Test development curves of no. 00 Hydrafiner

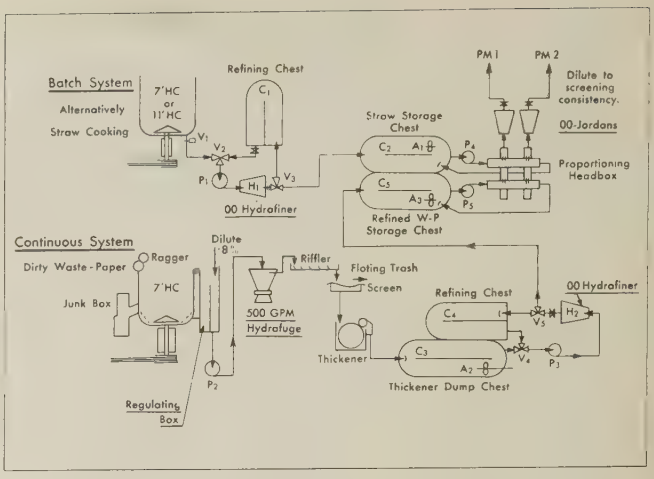


Fig. 20. Stock preparation system

likely to produce any cutting, but the result will be fibrillation on the surface fibers.

The action on the fibers as they pass between the faces of the two bars is one of alternating squeezing and releasing; the water being squeezed out and reabsorbed respectively. Consequently, the fibers will actually be treated in a very dry condition. Under such conditions, one can readily imagine that the small multitudinal fibers would become loosened from the surface of the main fiber.

In the Hydrafiner or any conical refiner, the following variables must be controlled and incorporated in the refiner design, in order to achieve certain production characteristics of the machine:

1. Bar construction.
2. Width of bars.
3. Arrangement of bars.
4. Number of bars.
5. Width of channels between bars.
6. Depth of channels.
7. Taper of plug and shell.

Fig. 21. Proportioning headbox

Table I. Steps in Mixed Waste Paper Low Density Slushing and Cleaning Systems

Type of operation	*Consistency, %*	*Equipment*	*Comments*
Feeding of furnish	Dry	Belt conveyor or skip hoist	Continuous automatic
Initial disintegration	1½–2½	Breaker beaters, pulpers	Temp. 25–60°C. continuous
Removal of large heavy particles	....	Junk removers or junk box	Junk removed by buckets or by hand
Removal of rags, ropes, wires, etc.	....	Rag catcher or automatic ragger	Batch or continuous operating
Primary removal of heavy dirt	0.6–1.2	Rifflers, settling cones, centrifugal pressure drop equipment	Continuous
Coarse screening of floating trash	0.8–1.5	Vibrating screens or Classifiner	Continuous; tailings for fiber recovery
Disintegration of floating trash for fiber recovery	1.5–2	Noncutting—brushing type of refiner; disintegrator	Continuous
Final screening of floating trash; recovery of fibers	1–2	Flat or rotating screens—Selectrap	Continuous
Concentration of accepted fibers	Inlet: 0.8–1.5 Discharge: 4–6	Drum concentrators, thickeners, or vacuum washers	Continuous
Final disintegration or defibering	3–6	Beaters and/or conical high-speed refiners and jordans	Batch or continuous; direct to machine or blending chest or headbox
Final dirt removal	0.8–1.2	Rifflers or centrifugal pressure drop equipment	Generally ahead of paper machine
Final screening	0.8–1.2	Flat or rotary open or closed screens	Generally ahead of paper machine

8. Length of plug and shell.
9. Diameters of plug and shell.
10. Pressure of stock within the unit.
11. Consistency of the stock.
12. Speed of the plug.
13. Speed of the unit as interpreted in terms of horsepower applied against speed: this is probably the most important concept of Hydrafiner design.

It will generally be recognized that low power versus high speed will tend to give gentle brushing, hydrating, and fibrillating action, regardless of the type of filling when compared with the same filling operating at low speed versus high power.

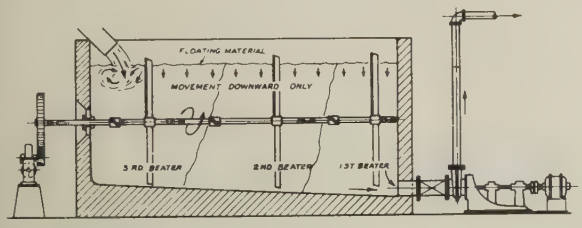
As the Hydrafiner is mainly designed for gentle brushing and fibrillating without very much cutting, in order to develop such strength factors as the tear and bending properties, this machine is running under the first principle—namely, low horsepower versus high speed.

Figure 18 shows the refining characteristics and the strength development in the Hydrafiner and the jordan range. It will be noticed the Hydrafiner will also develop (besides tear) rather limited burst test and tensile, while the drop in freeness is very low.

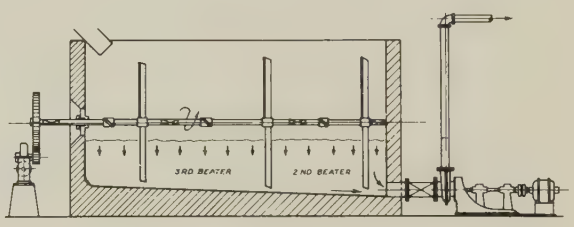
On the other hand, the jordan machine applies the opposite principle—namely high horsepower versus low speed. From the curve it will be seen that when the stock is treated in the jordan range, there is an extreme development of burst and tensile, while there is an outstanding decrease in freeness and fall in tear.

In order to show quantitatively the influence of horsepower versus speed, Fig. 19 gives test development curves from a no. 00 Hydrafiner test run in the laboratory on a normal kraft furnish at 5% consistency in a batch type duo-cycling system at 1200 and 1800 r.p.m., respectively.

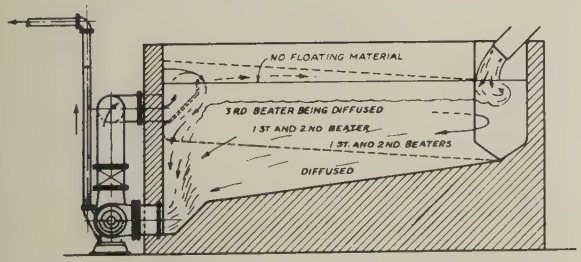
It will be seen that one set of curves is derived from stock passing the unit at 1800 r.p.m. with a constant power consumption of 75 hp. The other set of curves is derived from treatment of the same stock under the same conditions, but the Hydrafiner was running at 1200 r.p.m. By comparing the two sets of curves, it will be seen that higher tearing strength was developed with the higher speed, less freeness drop is encountered, and a smaller increase in burst and tensile is achieved. Then, conversely, at the 1200 r.p.m. curve a poorer development of tear, a greater reduction in freeness, and a higher development of bursting and tensile



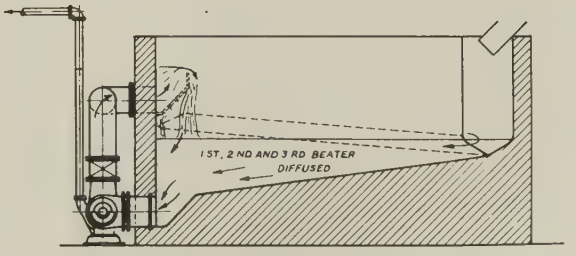
HERE, USING OLD TYPE EQUIPMENT, PADDLES CUT PATHS THRU THE STOCK INSTEAD OF AGITATING THE ENTIRE MASS.



HERE, WITH OLD TYPE EQUIPMENT, CONDITION IS WORSE THAN WITH FULL CHEST (ABOVE) BECAUSE THE PADDLES ARE ABOVE AND CLEAR OF THE STOCK MOST OF THE TIME.



HERE, WITH AN AGI-FLO UNIT, CONTINUOUS MOTION OF THE STOCK IS MAINTAINED, EVERY POUND BEING MIXED AND INTERMIXED. NO STRATIFICATION, CHANNELING, FLOATING STOCK OR DEAD AREAS.



HERE, WITH AN AGI-FLO UNIT, SAME THOROUGH AGITATION, MIXING AND BLENDING, ALTHOUGH THE CHEST IS LARGELY EMPTY. VARYING LEVELS OF STOCK MAKE NO DIFFERENCE.

Fig. 22. Agitation (paddle V. Agi-flo)

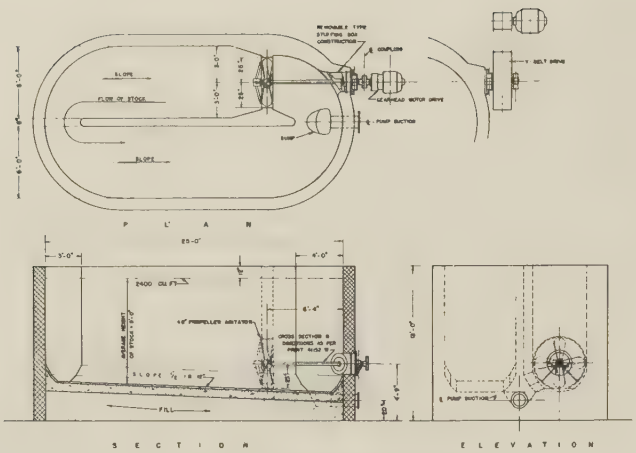


Fig. 23. Propeller agitators

strength will be noticed. This does not mean that all Hydrafiners should run at 1800 r.p.m. but will simply illustrate the effect of the speed differential and the effect of the horsepower versus speed theory. One fundamental concept, found to be borne out by mill experience, is that refining is only effective up to the maximum tear development of any fiber. After that point, if further strength development is required, the jordan refiner (that is, the cutting machine) is more efficient in terms of horsepower per ton per unit of strength or stock development.

From what has been mentioned here, it will be understood that the correct treatment should be given by a balanced refining and jordaning. The Hydrafiner and the jordan should be operating as a team, and it should be possible to emphasize one of the two as needed for the special paper or board required, or depending upon the raw material used.

Figure 20 shows a very general flow diagram of a stock preparation system for a low production two-machine mill or for a board machine.

This system is built up of a continuous waste paper system, including cleaning equipment, and a batch system for either liner stock for the liner vat or as furnish for another paper machine.

Special attention should be drawn to the waste paper system. It will be noticed that, from the thickener dump chest which will hold the cleaned waste paper stock, the pulp is pumped through a Hydrafiner and into a refining chest. When this refining chest is full, the valve V_4 on the suction side of the pump will be turned to take stuff from the refining chest and push this through the Hydrafiner once more.

In this way it is possible to cycle the stock through the Hydrafiner and give it several passes before it is finally discharged into the refined waste paper storage chest C_3.

On the other hand, with this installation there is also a possibility of running continuously from the dump chest through the Hydrafiner into the refined waste paper storage chest. In many applications it will be found that one pass through the Hydrafiner will be sufficient and in that case, of course, the continuous operation is simpler and will be preferred. In bigger installations, it might warrant to install two, three, or more Hydrafiners in series, in which case of course there will be the repeated treatment from one refiner to the other, and it will not be necessary to refine batchwise. However, the installation of this small recycling refining chest gives the old setup a much greater flexibility, and it will be possible to treat very hard-to-defiber stock.

The batch system is a straightforward refining system with slushing in a Hydrapulper and refining in the refining chest through the Hydrafiner; after refining the stock is discharged into the batch or liner stock storage chest, C_2.

This system is also applicable to cooking straw. In this case the chopped straw is dumped directly into the Hydrapulper and the chemicals are added, and after approximately $^3/_4$ to 1 hr.'s cooking the straw stock can be dumped into the refining chest, passed once or twice through the Hydrafiner, and dumped into the straw storage chest. This, of course, gives only a very low degree of cooking, but this straw pulp is a very good furnish for corrugated medium, for instance, and can be blended with the waste paper from the waste paper storage chest by means of the proportioning head box which is shown.

AGITATION

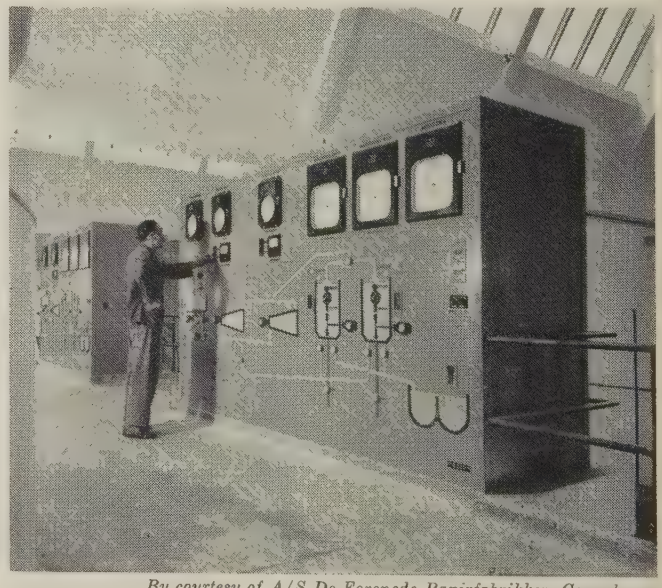
A very important point, especially in waste paper mills, is the question of proper agitation. All will realize that in waste paper, the furnish can vary greatly from one moment to the next and it is, therefore, very important that the stock is thoroughly mixed as soon as it is dumped from the thickener to the dump chest, in order to prevent rapid changes on the paper or board machine. If the changes are gradual, there might be time to adjust the jordans ahead of the machine inlet box after the machine chest, and there might also be time to notify the operators who are furnishing the waste paper to the Hydrapulper. The author strongly recommends that this question be taken seriously into consideration when building new chests and also when altering the design of existing dump chests.

A very efficient agitator is the Agi-Flo pump which, besides agitating, will deliver a constant flow of stock to the next operation regardless of the level of stock in the chest. The centrifugal pump and agitator impeller are fitted on the same shaft and driven by the same motor.

Figure 22 shows that, with the old type paddle agitators, the stock will separate in layers in the chest. The mixing (as it will be seen) is not very efficient. This separation and inefficient operation of the agitator is especially noticeable when the level of stock in the stock chest is very low.

In comparison with this old type agitator, the figure also shows the application of the Agi-Flo pump, which gives very good agitation and blending and operates efficiently even at low stock levels. This type of agitator also levels out any small changes in consistency that might arise from the thickener, thus giving a uniform stock.

Another type of agitator is the propeller agitator which, correctly designed and applied, gives a very good agitation in all types of stock. One special feature of these propeller agitators, as shown in Fig. 23, is that the pitch of the blades can be varied according to the freeness of the stock and the consistency of the stock. By having this possibility of varying



By courtesy of A/S De Forenede Papirfabrikker, Copenhagen

Fig. 24. Central control panel for stock preparation

the pitch, it is always possible to adjust the horsepower taken by the agitator to an absolute minimum in order to give adequate agitation.

CENTRALIZED CONTROL PANEL OPERATION

This paper about modern stock preparation systems should not be concluded without mentioning the centralized control panels. Today's trend toward remote control operation of mill equipment is the most significant development in the industry in many years. Older mills are operating their Hydrapulpers and refiners by push button, and they are installing electrically operated valves. Mills more recently built are adopting control board operation throughout. It is nothing unusual to count a dozen or fifteen boards of various types and sizes in a modern paper or board mill.

In order to give an idea of a centralized control panel, the author secured permission to include a photograph taken of an installation in Scandinavia (Fig. 24). It will be noticed how the whole flow diagram is shown on the board and all the various signals and valve indications are readily accessible for the operator and easy to handle. This, of course, is not a board system but a system for sulphite groundwood specialties, having one control system for the groundwood and one control system for the sulphite.

From the control panel the operator can start and stop the Hydrapulper, open the dump valve, start the Hydrapulper dump pump, start and stop the refiners and even adjust the setting of the plug. He can also change the position of all the electrically operated valves that are included in the system.

With this control panel there is very little possibility of mistakes, and it has shown out in practice that this type of control equipment pays for itself in security, reduction of labor force, and uniformity of the stock treatment, which reflects upon the final produced paper or board.

CONCLUSIONS

Unfortunately, space does not permit the author to go into further detail with subjects such as the deinking of waste paper or reslushing of machine broke, which naturally would fall under the category of waste paper treatment.

It appears that the last 10 to 15 years have shown a definite alteration in the practice of papermaking, inasmuch as more emphasis has been put upon specific machines to do specific jobs. It has also been the practice in the last few years to install as many instruments as possible in the mill in order to follow the operation much more closely. This way the craft of papermaking is moving more toward the scientific side, but will still in the future maintain quite a lot of the craft and skill that was the pride of papermaking in the original trade. Admittedly, there are still many fields which will have to be explored and many questions which are as now unanswered, but it is believed that the close cooperation between the equipment supplier and the papermaker and the actual paper mill operator, is of the very greatest importance, in order to develop new and more efficient equipment for the paper trade to mutually benefit the papermaker and the equipment builder.

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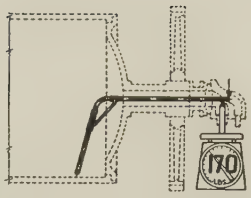
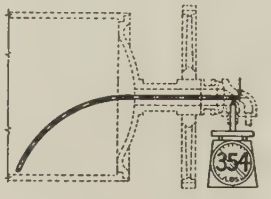


Reaction of ¾" Auto-Flex in 48" diameter dryer. Very low leverage.



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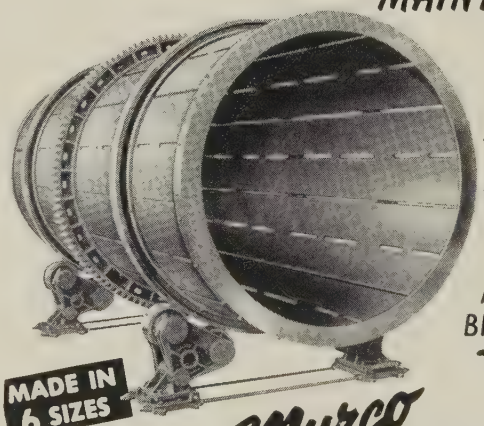

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Second Mechanical Pulping Conference, Poland Spring House, Poland Spring, Me., September 19–21, 1955.

Fifth Testing Conference, Hotel Sheraton-Kimball, Springfield Mass., September 28–30, 1955.

Fifth Corrugated Containers Conference, Morrison Hotel, Chicago, Ill., October 5–7, 1955.

Ninth Alkaline Pulping Conference, Hotel Patten, Chattanooga, Tenn., October 19–21, 1955.

Tenth Engineering Conference, Rice Hotel, Houston, Texas, November 7–9, 1955.

Tenth Plastics-Paper Conference, Brooklyn Law School, Brooklyn, N. Y., November 14–15, 1955.

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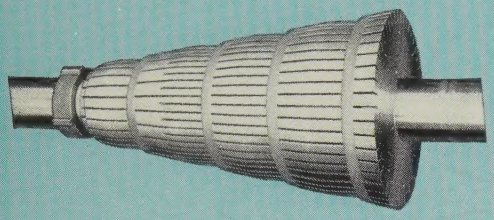

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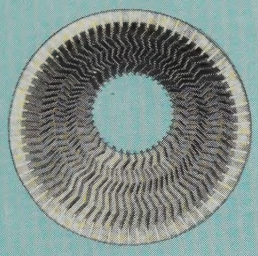

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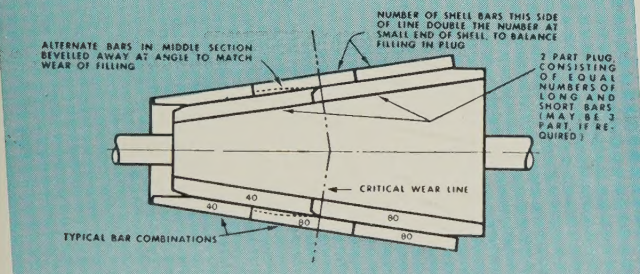
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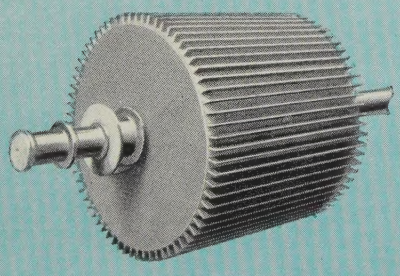

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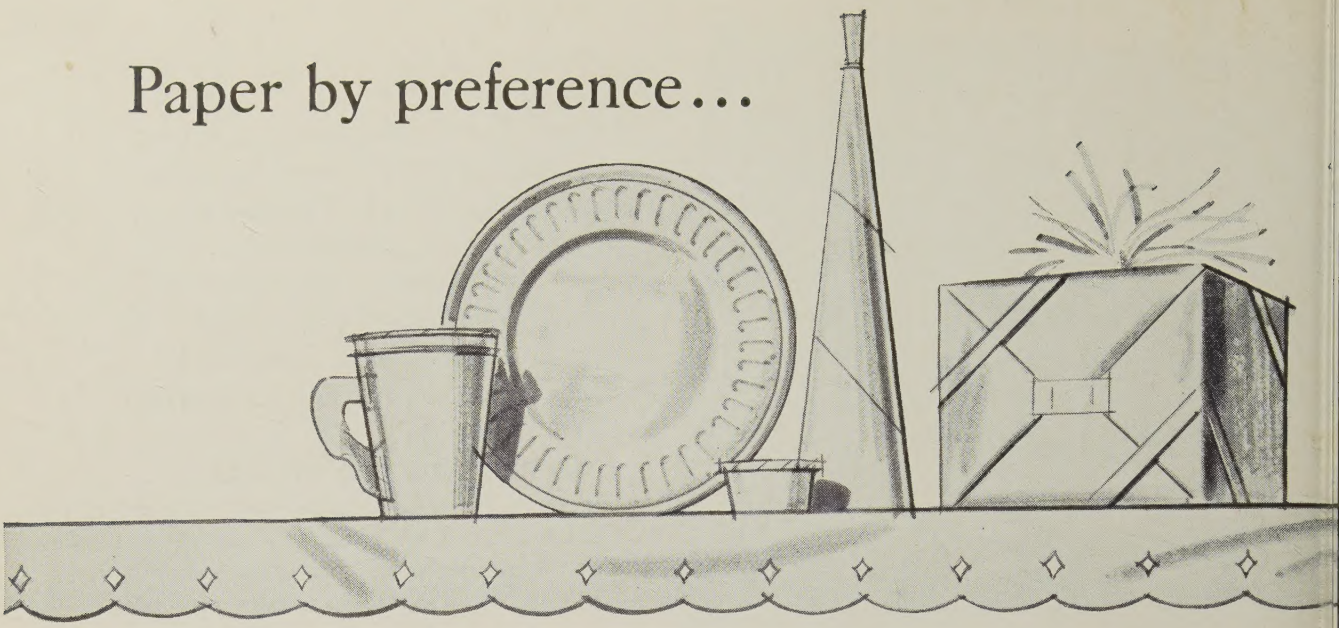

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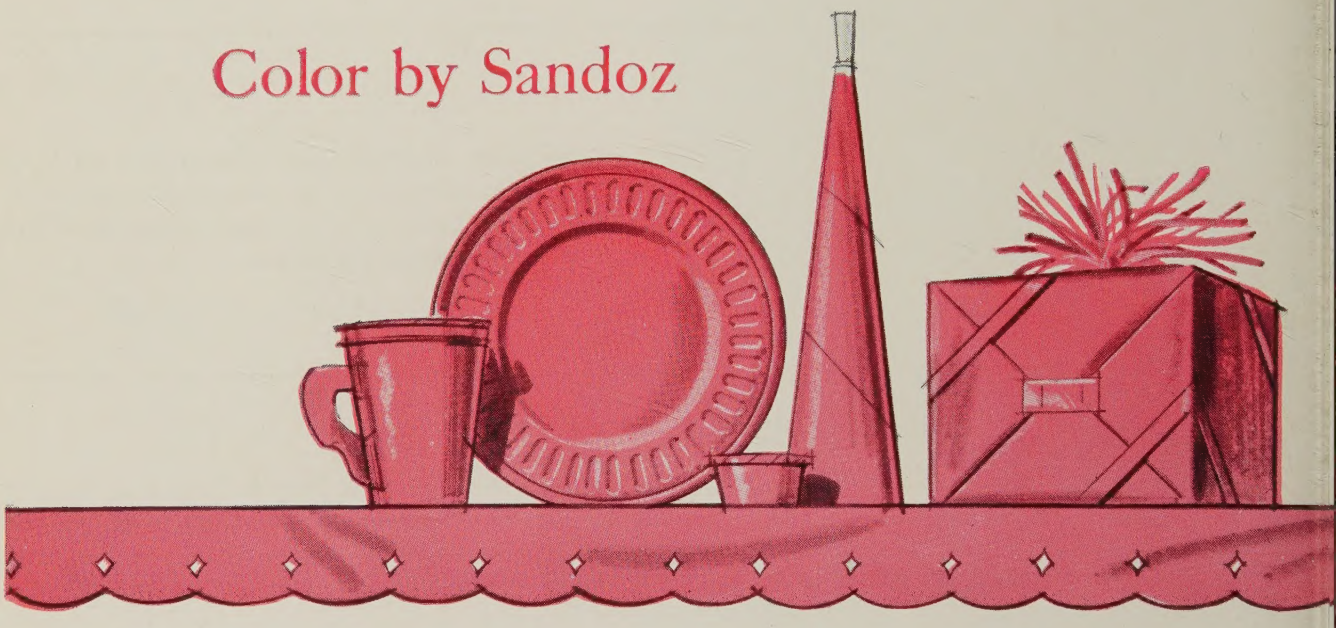

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